HYDROBIOLOGIA ;
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Objectionable Algae
with reference to the killing of fish and other animals

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Several species of blue-green algae (Cyanophyta) are notoriously successful in creating disturbances in lakes, ponds and reservoirs, often leading to great economic loss. The principal offenders are *Aphanizomenon flos-aquae* (L.) Ralfs, *Microcystis aeruginosa* (Kuetz.) Henfrey, *Microcystis flos-aquae* (Wittr.) Kirch., *Gloeotrichia echinulata* (J. E. Smith) P. Richter, and several species of *Anabaena*. The many objectionable effects produced by these algae arise mostly from two of their characteristics, namely: their ability to reproduce rapidly during warm seasons, and their habit of floating high in the water. These tendencies often result in thick surface scums which subsequently decompose; thus setting off a chain of events which upset the biology of a body of water.

It is rather paradoxical that algal pests such as *Aphanizomenon* and *Microcystis* follow along after and are associated with human disturbances in and about lakes. Ecological conditions in lakes which favor the growth of these plants are high nitrogen and phophorus content (See Table 1.), high carbon dioxide reserve in dissolved bicarbonates, and high temperatures (26—30 C.). Hence in warm, hard water lakes where essential nutrients are abundant, algae, especially blue-greens, find suitable habitats for superabundant growth. In virgin lakes the *purée* type of „bloom", common to lakes in thickly populated centers, is rare indeed. But lakes which receive drainage from tilled soil, sewer effluents, excreta from farm animals and barnyard drainage, or refuse from city streets and factories, or from summer resort centers, become veritable garden spots for algae. Vegetation in such lakes behaves much as do crops on a fertilized tract of land; but with one notable difference however, in that there is generally a continual increase of fertilizing substances in aquatic habitats. Consequently the lake becomes more and more suitable for algae growths as it becomes older, shallower, and warmer for longer periods of time during the year.

Other algae besides those mentioned may be guilty of causing

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Table 1

Average number of blue-green algae per litre of water compared with some chemical analyses in six Iowa lakes

(Collections made in July and August)

Lake	Av. Summer Temperature	Album. Nitrogen	Ammon. Nitrogen	Nitrate Nitrogen	Phosphates	Alkalinity	pH	No. of organisms p. litre
Storm	28	1.21	0.52	0.1	0.08	195	8.7	3,000,000
Center . . .	27	0.60	0.45	0.3	0.10	220	9.5	2,000,000
Diamond . . .	22	0.50	0.30	0.1	0.08	190	9.1	600,000
Spirit	24	0.20	0.1—0.2	0.0	0.01	204	8.7	909,000
East Okoboji .	30	0.40	0.40	0.40	0.10	250	8.7	300,000
West Okoboji .	19—20	0.0	0.0	0.10	0.004	—	7.1	140,000

trouble, usually in the shallower (eutrophic) lakes and slowly flowing streams. About 65 species are known to cause „blooms" in lakes, but few of these produce growths that induce climax or critical conditions. The most common offenders, in addition to the blue-green algae mentioned above, are *Dinobryon* spp. *(sertularia, sociale)*, *Synura uvella* Ehr., and diatoms such as *Fragilaria* spp. *Melosira* spp., and *Synedra* spp.

Even when alive and healthy these plants impart disagreeable „fishy" tastes and odors to water and create a nuisance in lakes which are a part of a municipal water system. But when they die in great masses, products of their decay make them all the more obnoxious, especially blue-green algae because they are rich in proteins and other nitrogen-bearing substances (See Table 2.). As these undergo decomposition malodorous gases and disagreeable tastes are produced. Indeed some of the by-products of decomposition are apparently poisonous, at least for fish. Simple laboratory experiments with decaying blue-green algae show that, among others, methane gas is produced. The necessary measures to rid the water of algae and to neutralize the tastes are expensive of course.

Again, municipal water systems which incorporate sand filters that are exposed to light frequently experience difficulties. The filters are rendered inadequate by the matting produced when thick layers of algae cause a loss of head in the filter system. Especially diatoms such as *Fragilaria, Tabellaria, Melosira* (filamentous forms) together with the stalked and at-

Table 2

Chemical analyses of various organisms stated in percentages of dry weight of the sample (*)

Organism	Nitrogen	Crude Protein
Cyanophyta		
Microcystis	9.68	55.68
Anabaena	8.91	60.56
Aphanizomenon . .	10.05	62.83
Coelosphaerium and		
Anabaena	8.75	54.74
Lyngby	9.73	60.81
Chlorophyta		
Spirogyra	3.81	23.82
Cladophora	3.77	23.56
Crustacea		
Diaptomus	11.03	68.93
Cyclops	10.15	63.43

(*)   After Birge and Juday.

tached *Gomphonema,* and the blue-green genus *Phormidium* create a compact film of ,,Schmutzdecke". Besides interfering with the physical operation of the filter such a dense blanket of algae impart disagreeable tastes to the water as it passes through. Occasionally the algae interfere in another way. In the ,,Schmutzdecke" the numerous organisms continually release gases during photosynthesis and respiration. These gases (carbon dioxide and oxygen) form bubbles in the film and cause large patches of it to break loose and float leaving the sand bare in some places. This results in too rapid filtration in some areas of the bed, while it is still inhibited in others.

Another type of damage is fortunately of rare occurrence but is serious, nevertheless, to the economy of individuals effected. Many reports have been made of cattle and other domestic animals dying after drinking water heavily infested with algae, especially blue-greens. As early as 1878 (Australia) an account is recorded of the death of cattle attributed to algae. From many parts of this country, particularly in the middle west, there are such cases on record. In 1945 the author received samples of algae (decomposed *Aphanizomenon flos-aquae* (L) Ralfs) from Bermuda where cattle had died after drinking from pools (or troughs) in which the plants had formed a dense ,,bloom". All such reports of cattle and fowl dying from drinking algae-infested water were unsubstantiated until the problem was carried to the laboratory. In 1934 Fitch, Bishop, *et al,* published on the results of their experiments with blue-green algae and laboratory animals. They demonstrated the toxic and lethal effects of such species as *Microcystis flos-aquae* (Wittr.)

Kirch., *Anabaena flos-aquae* (Lyngb.) Bréb., and *Aphanizome-non flos-aquae* (L) Ralfs on guinea pigs, rabbits, and pigeons. It is noteworthy that the toxin with which they were working was not effective after the plants had died, but was present in the water in which the plants were living as determined by injection experiments, and by feeding. Although the toxin was not isolated these authors determined a number of its proper-ties, and whereas the experiments were not conclusive, they do contribute convincing evidence of the ability of algae to cause death of cattle and other animals. Further confirmation comes from Steyn (1945) who reported cases of poisoning of animals in South Africa. A toxin produced by *Microcystis* sp. was found to be capable of producing pathological conditions (constipation, drop in milk production, etc.) and eventually death in cattle, sheep, and other animals; also reported by Edith L. Stephens.

Still another detrimental effect of algae „blooms" arises from their ability to kill fish, either directly or indirectly. While carrying on some investigations for the Iowa State Fish and Game Commission in the lakes of northwestern Iowa, opportu-nity was afforded the auther to see the effects of blue-green algae at their worst. Especially in East Okoboji Lake, but also in Storm Lake and others, tremenduous „blooms" of blue-greens developed periodically during the warm summer months. It was noted on several occasions that death of fish (often by the hundreds of thousands) occurred after algal „blooms" had under-gone sudden decay — a great discouragement to the fisherman and the conservationist. On still, hot nights, when the oxygen content was low in any case, the tremenduous decomposition activity of bacteria usually depleted the oxygen below the point which would support most fish life (3 ppm.). Frantic attempts to remedy such situations by artificial aeration helped a little, but often did more damage than good. It is thought probable that dense „blooms" are able to bring about the death of fish more directly than this by causing a depletion of oxygen through their own respiration. Photosynthesis during the daytime of course maintains an adequate supply of oxygen for plants, but at night, with respiration continuing and with oxygen as low as 4 ppm. at the outset, the minimum point soon can be reached.

Observations made by the author and by several fish biolo-gists on the survey of the Iowa lakes indicated that fish were being killed by other means than by suffocation. Especially in shallow bays and near shore fish *(Perca flavescens* Mitch., *Le-pomis gibbosus* L., *Ameiurus melas melas* Raf.) were found dead without showing symptoms of having been suffocated. Neither did they show evidences that they had died from disease. This led to the speculation that the fish may have been poisoned. Consequently a series of laboratory tests were undertaken to determine that possibility.

Tanks at the East Okoboji (Iowa) stripping shed were used.

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These were twelve feet long, four feet wide, and about three feet deep. The tanks were partly filled with lake water and seven species of recently seined fish were put in them. The fish used were 3 crappie *(Pomoxis nigro-maculatus* L S.), 2 gizzard shad (imported) *(Dorosoma cepedianum* Le S.), 1 golden shiner *(Notemigonus crysoleucas* Raf.) 1 orange-spotted sunfish *(Lepomis humilis* Gir.) 2 fathead minnows *(Pimephales pro-melas promelas* Raf.) 1 bluegill *(Lepomis macrochirus* Raf.), and 1 buffalo (*Megastomatobus cyprinella* Vol.).

A tank of compressed oxygen was connected by a rubber tubing to a short length of pipe with fine outlet holes. The pipe was laid in the bottom of the tank and a flow of oxygen was permitted to bubble through the water. The oxygen stream was regulated by a valve on the tank. The flow was allowed to con-tinue for three hours and readings were made periodically to determine the ability of the flow to raise the dissolved oxygen above the concentration necessary to support fish. The D. O. readings varied from 4—6 ppm.

Twenty gallons of algae *(Aphanizomenon flos-aquae)* were collected, allowed to decompose in large milk cans, and then added to the tank containing the fish. The initial D. O. reading in the aquarium was 4.0 ppm. Within thirty minutes the fish began to behave peculiarly and erratically. Several struck violently against the sides of the aquarium. Only occasionally did a fish come to the surface, but none showed signs of being in distress from lack of oxygen. Within an hour several fish appeared to be dying, swimming on their sides, or lying on the bottom. Dissolved oxygen readings were taken at frequent in-tervals. It never dropped below 4.0 ppm., and when one buffalo and one crappie died it was 4.6 ppm. Within six hours all the fish were dead except one crappie. At this time the D. O. was 4.2 ppm.

Similar experiments were performed using smaller glass aquaria and tap water from the city mains of Storm Lake, Iowa. This water had a D. O. content of 4.8 ppm. Using an oxygen tank as before it was increased to 12.6 ppm. About five gallons of decaying *Aphanizomenon flos-aquae* (L) Ralfs were poured into the aquarium which contained eight species of fish: sheeps-head *(Apodinotus grumniens* (Raf.), minnow *(Hyborhynchus notatus* Raf.), perch *(Perca flavescens* Mitch.), bullhead *(Amei-urus melas melas* Raf.), orange-spotted sunfish *(Lepomis hu-milis* Gir.), golden shiner *(Notemigonus crysoleucas* Raf.), pumpkinseed sunfish *(Lepomis gibbosus* L.), and carp *(Cypri-nus carpio* L.). These ware all small fish, 4 to 6 inches in length.

The glass aquarium made it possible to watch the behavior of the fish in spite of the density of suspended matter. As in the previously described experiment the fish behaved erratically within thirty minutes. The sheepshead died in two hours, the others after longer periods until at the end of five hours all

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were dead. Oxygen readings taken during the exposure time indicated that the fish had not died from suffocation, thus strongly suggesting the probability of their having been poisoned.

In order to test the effect of decomposed blue-green algae on fish under more natural conditions a simple experiment was set up on a flat beach along Storm Lake. Ponds, each about 25 feet square and 3 feet deep, were excavated in such a way that fresh water could enter them. Heavy screening was placed in the gateways so that fish might be retained and fresh water allowed to circulate. A drainage system was provided so that stagnant water might be drawn into low areas and the ponds refilled with water. Lake water carrying a heavy load of *Aphanizomenon* was allowed to flow into the pond, then the gate was dropped and the plants allowed to disintegrate in the shallow warm water. Within half an hour the water became tinged with blue as the natural pigment (cyanophycin) was liberated from the algal cells. A dissolved oxygen test showed sufficiency to support fish life (D. O. 7.5). Six fish, seined from the lake in the immediate vicinity of the pond were placed in it. These were crappie (*Pomoxis nigro-maculatus* Le S.) carp *(Cyprinus carpio* L.), and bull heads (*Ameiurus melas melas* Raf.). Within one hour the carp were dead and none of the fish were alive at the end of two hours. At no time did they behave as though suffering from a lack of oxygen, and D. O. tests taken throughout the experiment showed sufficient oxygen to be present.

Decomposed blue-green algae were analyzed chemically. It was found that a poisonous protein decomposition product, hydroxylamine, was present in quantities sufficient to kill fish. (Chemical tests were run in such a way that volumetric percentages were not obtained.) Also sufficient amounts of hydrogen sulphide to kill fish were found to be given off in decomposing algae. Quantitative tests showed 8.5 ppm. of H_2S in the sample analyzed. The writer was informed by the analyst that this figure was far below the actual concentration because much of the gas was lost during distillation. How sensitive fish are to H_2S the writer is unable to state, but, suffice to say, this gas is poisonous and could have been liberated in quantities sufficiently great to kill fish exposed to great masses of decaying algae in shallow water.

Control Measures.

The harmful effects of algae in lakes and reservoirs have necessitated the use of control measures. The loss of fish, the spoiling of recreational sites, the ruining of drinking water, make them the bane of the municipal water plant operator, the health officer, and the conservationist.

Of the various means used to remedy situations the well-

known copper sulphate treatment is still the most feasible from the standpoint of cost and efficiency. Inasmuch as copper sulphate (blue-vitrol) is a poison its use is often objected to by fish and game officials, by fishermen, and by the inexperienced citizen. One answer to all such objections is that copper sulphate can be used in such minute concentrations that it is not injurious to drinking water, nor to fish life, especially when applied correctly. Naturally it should not be used in such concentrations as to kill *all* algae and other microscopic life because in so doing the basic fish-food organisms would be destroyed, thus removing the fundamental basis of the food-chain.

In the United States, copper sulphate has been used since the early work of Moore and Kellerman (1904). Varied results have been obtained by municipal engineers and health officers in their attempts to deliver good drinking water or to improve lake conditions, Some of the results have been disappointing. Experiences of the writer and observations of the use of copper sulphate by others indicate that the following points should be taken into consideration.

1.   The chemistry of the water, varying in different lakes and reservoirs, determines, in part, the effectiveness of copper sulphate. When the chemical goes into solution it ionizes to form Cu and SO radicals, with 10 % left in the molecular form. The copper unites with the protoplast of living cells, killing them and causing them to sink. The ions react with substances in the water, however, to form copper carbonate and calcium sulphate, with some liberation of carbonic acid. The copper carbonate then breaks down and reacts with hydroxide ions to form copper hydrate which is insoluble and which settles out, thus rendering the copper definitely ineffective. The more basic (harder) a lake is, the greater the amount of chemical reaction and the less copper there is left to unite with living cells. Thus the usually recommended concentrations of copper sulphate may have to be increased, as determined experimentally, to ascertain an effective dosage. (See Table 5).

To show the reaction of copper sulphate in hard and soft water a series of tests were made in the laboratory, using standard solutions of known pH value. To solutions ranging in pH from 6.0 to 8.9 equal amounts of copper sulphate solution were added. There was a precipitation of copper sulphate scarcely present in the tube with a pH of 6.0, but this increased proportionately through the series to pH 8.9.

A series of laboratory tests were carried out to determine the fate of algacidal copper. Samples of blue-green algae were killed with copper sulphate and then washed with distilled water. The washings were tested for copper with negative results. Then portions of the sample were treated with dilute HC1 and washings again were tested for copper, but with negative

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results. A sample of the treated algae was then put in a muffle and burned at a temperature of 700 degrees C. for 2 hours. The ash was removed and tested which showed by electrolytical analyses that 0.001 per cent of copper by weight was present. This proved that the copper had united chemically with the algae and was not merely adsorbed as is often claimed. It is thought that the union is with proteins of the protoplast inasmuch as it is well known that protein colloids are quick to react with copper. That copper is later released from the algae to accumulate on the bottom has been disproven by results obtained from repeated bottom analyses. Whereas the water contains little or no free copper, copper compounds occur in the sludge from lake bottoms to a depth of 4 feet (Madison lakes, Sawyer, et al, 1944). The fate of all the copper used in treating such bodies of water as the Madison lakes where the chemical has been used for ever twenty years, is not known.

2. The normal life cycle of the contaminating alga must be taken into consideration. If a lake or reservoir is to be treated effectively the chemical should be applied at a time when it will have the greatest inhibitory effect. Not infrequently expensive treatments are undertaken only when the algal „bloom" has become noticeable, or after a resort owner has complained that the water along his beach is unusable, or after drinking water that has developed a disagreeable taste. Then it is too late to clear up a condition efficiently. Obviously a close check should be made beginning early in the seasons in which algae are known to develop „blooms", so that at the first sign of an alarming increase (as determined by microscopical examination of plankton hauls) an application of the chemical can be made. This will save costly and repeated treatments later. To the tax-paying casual observer an early treatment seems unwarranted and may call forth complaints of extravagance because objectionable algal growths are not obvious. An experienced aquatic biologist can easily determine when the chemical should be applied by making periodic examinations.

3. The method of applying the chemical must be modified to meet particular situations. The size of the body of water to be treated, the time of year, the temperature, the nature of the growth (floating or dispersed), and whether special effort must be made to save fish, are some of the determining factors. Continuous dry feeding in reservoir acqueducts is used by some engineers (Hale in New York, 1930, e.g.). This method obviously can be used only where there is a narrow and controlled inlet to a reservoir.

For the general treatment of large lakes the „drag method" is the simplest, but in many cases less effective. After the quantity of copper sulphate has been determined (by measuring the volume of water and calculating the pounds of copper necessary to produce the required concentration) bags of the crystal

are dragged behind row boats or launches. The drag method used at Storm Lake, Iowa was found to have varying degrees of success, depending upon the density of the algal growth, wind direction, etc. Concentrations as low as one pound per million gallons of water is the usually recommended dosage for the pest *Aphanizomenon flos-aquae* (L) Ralfs which occurs in this lake. Storm Lake is a shallow, saucer type and the water is much roiled by wind action. The water is hard which means that there is an abundance of calcium carbonate. Hence the minimum dosage was often hardly sufficient to give desirable results (for reasons explained above). It was found that when the dosage was increased (to 2 or 3 lbs. per million gallons being recommended) that a much more effective treatment resulted, especially for the eradication of dense growths of algae in the windward portions of the lake.

A fault of the drag method lies in the fact that water in the immediate vicinity of the boat wake receives a dosage heavy enough to kill fish, should any stray into the zone before the salt has dispersed. Ordinarily, however, fish are driven from the vicinity of the copper sulphate by the motion of the boat. The writer has never seen a case of fish poisoning from copper sulphate when ordinary recommended precautions were used in the application. Some laboratory experiments were carried on to test the concentration of copper sulphate which fish of various species could withstand. The results of these tests are shown in Tables 3—4. The figures show the concentrations which did not kill fish and do not represent the minimum lethal dosage necessarily. For comparison a table of concentrations of copper sulphate reported to be lethal for fish of other species is given (Table 4). It will be noted that the figures are well above the concentrations of the salt ordinarily used to control blue-green algae. (See Table 5).

An older, much used method, and in general a more effective one, is that of spraying. This method is highly satisfactory at Madison, Wisconsin (Domogalla, 1935). It has the distinct advantage of distributing the chemical in such a way that as it

Table 3

Concentrations of copper sulphate found to be safe for fish in Storm Lake, Iowa

Fish	Parts per million	Lbs. per million gallons
Gar pike	0.46	3.75
Sheepshead	0.46	3.75
Catfish	0.58	4.70
Blue-Gill	0.46	3.75
Silver bass	0.46	3.75

Table 4

Reported concentrations of copper sulphate lethal for fish

Fish	Parts per million	Lbs. per million gallons
Trout	0.14	1.2
Carp	0.30	2.5
Catfish	0.40	3.5
Pickerel	0.40	3.5
Goldfish	0.5	4.0
Perch	0.75	6.0
Sunfish	1.2	10.0
Black bass	2.1	17.0

diffuses and sinks it comes in contact with the maximum amount of vegetation. This is particularly desirable for a treatment of *Aphanizomenon* and *Microcystis* „blooms" in as much as they are plants which characteristically float at or near the surface. In Madison the copper sulphate is put into solution (about 5 %) in wooden vats on a barge which is towed by power boats. From the vats the solution is pumped through sprays which are either manipulated or operated mechanically from the rear of the barge so that a zone fifty feet wide can be treated at one time.

Concentrations of Copper. Sulphate.

The widespread and general use of copper sulphate has furnished us with an abundance of recommendations for determining concentrations. It is necessary to remember, however, that any one lake or reservoir has its own peculiar set of conditions (mentioned above). These have to be considered in determining effective dosages and a certain amount of experimentation must be done. (See Tables 5—6).

Chlorine (0.3—1.0 ppm) may be used to control objectionable algae and bacteria. Superchlorination is, of course, a standard practice of long standing, and is effective where dosage can be carefully regulated at inlets to reservoirs or treatment plants. It has the double advantage of neutralizing odors and tastes in addition to killing objectionable organisms.

Other algacides and weed-killing chemicals such as Benoclor-3 are being tried, but as yet are in the experimental stage. Tests which have been made (Gibbons, 1940) suggest that Benoclor-3 when used 12 gallons per acre may prove effective in reducing algal nuisance. Such a chemical, however, produces a noticeable taste which may require as long as 33 days to eliminate according to Gibbons (l. c.).

Table No. 5

Recommended concentrations of copper sulphate for the treatment of some of the more common forms of algae

Algae	Hale		Whipple		Domogalla (*)		Prescott	
	ppm	Lbs per million gallons	ppm	Lbs per million gallons	ppm	Lbs per million gallons	ppm	Lbs per million gallons
Aphanizomenon	.12-.5	1-4.2	.12-.5	1-4,2	.06-.1	.5-.9	.12-.5	1-4.2
Microcystis aeruginosa	.12-.25	1-2.1			.06-.1	.5-.9	.12-.5	1-4.2
Anabaena spp.	.12	1.0			.06-.1	.5-.9	.12-.5	1-4.2
Coelosphaerium spp.	.2-.33	1.7-2.8	.2-.33	1.7-2.8				
Synedra	.36-.5	3.5-4.2	.5	4.2	.06-.1	.5-.9		
Melosira	.33	2.8	.33	2.8				
Stephanodiscus							.12-.5	1-4.2
Fragilaria	.25	2.1			.06-.1	.5-.9	.12-.5	1-4.2
Asterionella	.12-.2	1.0-1.7						
Scenedesmus	1.0	8.3	1.0	8.3	.06-.1	.5-.9		
Hydrodictyon	.1	0.8	.1	0.8	.06-.1	.5-.9		
Dinobryon	.18	1.5	.25	2.1				
Ceratium	.33	2.8	.33	2.8	.06-.1	.5-.9		
Mallomonas	.5	4.2	.5	4.2				

(*) Using the spray method.

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Showing effect of copper sulphate treatment in Lake Monona June-July (*)
Number of organisms per litre of lake water

Algae	Just before treatment	3 days after	9 days after	20 days after
Anabaena	220,000	88,500	55,400	29,800
Microcystis	150,500	74,600	46,800	42,600
Fragilaria	74,100	39,000	29,800	11,300
Pediastrum	51,500	30,200	19,900	14,200
Synedra	45,600	25,300	17,000	18,500
Hydrodictyon	40,200	19,800	12,700	22,700
Aphanizomenon	38,400	18,000	11,300	11,300
Rivularia	29,600	15,500	7,100	7,100
Ceratium	20,800	7,300	2,200	2,200
Scenedesmus	16,900	5,500	5,600	5,600
Total number	735.600	353,000	165,300	165,300

(*)   Adapted from Domogalla, 1935.

Summary.

1.   The most troublesome algae in lakes and reservoirs are
species of blue-greens which have the ability to multiply rapidly
and which tend to float high in the water, forming surface
scums.

2.   Critical conditions arising from a superabundant growth
of algae occur in lakes which are shallow, warm, rich in nitro-
gen and phosphorus, and well supplied with half-bound carbo-
nates.

3.   Dense ,,blooms" of algae are particularly annoying and
often cause economic loss because of their ability to ruin recrea-
tional sites, spoil drinking water, clog sand filters, kill fish
(directly or indirectly), and kill animals which drink from
heavily infested lakes.

4.   Experiments are described which indicate that fish may
be poisoned by protein decomposition products such as hy-
droxylamine, or by H_2S that are released when dense masses
of blue-green algae decay.

5.   The factors which should be taken into consideration to
treat a lake effectively with copper sulphate are listed.

6.   The advantages of the spray method of applying copper
sulphate are pointed out.

7.   A laboratory experiment to test the algacidal action of
copper is described.

8.   Figures are given to show that fish can withstand concen-
trations of copper sulphate which are much greater than those
needed to control algae.

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Literature.

1. DOMOGALLA, B. 1935. Eleven years of chemical treatment of the Madison Lakes: Its effect on fish and fish foods. Trans. Amer. Fish. Soc., 65: 115—120.
2. FITCH, C. P., Bishop, L. M., et al. 1934. „Water bloom" as a cause of poisoning in domestic animals. Cornell Veterinarian, 24: 31—40.
3. GIBBONS, M. M. 1940. The use of „Benoclor-3" in potable water supplies. Water Works and Sewerage, May, 1940 (unpaged reprint).
4. HALE, F. E. 1930. The control of microscopic organisms in public water supplies, with particular reference to New York City. Jour. New Eng. Water Works, 44: 361—385.
5. MOORE, G. T., and KELLERMAN, K. F. 1904. A method of destroying or preventing the growth of algae and certain pathogenic bacteria in water supplies. U.S. Dept. of Agric., Bur. Plant Industry, Bull. No. 64: 9—44.
6. MOORE, G. T., and KELLERMAN, K. F. 1905. Copper as an algicide and disinfectant in water supplies. Ibid., Bull. No. 76: 5—55
7. PRESCOTT, G. W. 1931. A report on a study of some biological problems in certain Iowa lakes. Rept. to Iowa State Fish and Game Commission.
8. PRESCOTT, G. W. 1932. Copper sulphate as an algacide in lakes and reservoirs. Collecting Net, 7, No. 8 (unpaged reprint).
9. PRESCOTT, G. W. 1938. Objectionable algae and their control in lakes and reservoirs. Louisiana Municipal Review, 1 (unpaged reprint).
10. PRESCOTT, G. W. 1939. Some relationships of phytoplankton to limnology and aquatic biology. Problems of Lake Biology: Symposium. Publ. No. 10, Amer. Assoc. Adv. of Science. Science Press.
11. SAWYER, C. N., et al. 1944. Investigation of the odor nuisance occurring in the Madison Lakes particularly Monona, Waubesa, Kegonsa from July, 1943 to July, 1944. Mimeo. Rept. to Governor W. S. Goodland.
12. SMITH, G. M. 1920. Phytoplankton of the inland lakes of Wisconsin. Wis. Geol. and Nat. Hist. Survey, Bull. No. 57, Part. I.
13. SMITH, G. M. 1924. Ecology of the plankton algae in the Palisades Interstate Park, including the relation of control methods to fish culture. Roosevelt Wild Life Bull., 2: 88—195.
14. STEYN, D. G. 1945. Poisoning of animals and human beings by algae. South African Jour. Sci., 41: 243—244.

Microcystis Toxica sp. nov. a poisonous alga from the Transvaal and Orange Free State

(Summary of paper read May 16th 1945 before the Royal Society of South Africa and to be published in the Transactions of that Society).

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This alga first came into notice after the building of the great Vaaldam in the Transvaal (5 miles long, capacity 220 thousand million gallons), which was completed in 1938. Stock were dying along the bank by the end of 1940. By the end of 1942 a vigorous water-bloom of this alga extended over 98 % of the dam. Thousands of sheep and cattle died; many other kinds of animals found dead nearby were probably killed by the alga, but feeding experiments were confined to sheep and cattle. These experiments conclusively proved the alga to be responsible. The living species contains one of the most potent and destructive liver poisons known, but the dried alga is much less toxic. Animals drinking at a mildly infected ,,pan" (i.e. a shallow sheet of water, varying in size from a pool to a small lake) may not die, but only show a falling-off in condition. In the past, various ,,pans" have acquired a bad reputation among farmers as containing ,,bad" water for stock; the presence of this alga is the probable cause. It is widespread in S. E. Transvaal and N. E. Orange Free State, but is so far not recorded elsewhere. Treatment with copper sulphate has proved successful in keeping it in check at Vaaldam.

The alga is closely related to *M. aeruginosa*, but constitutes a separate species. The colonies average 1 mm. in diameter; when mature, they consist of a peripheral network of strands and balls of close-packed cells and are of all sorts of extraordinary shapes. It differs from *M. aeruginosa* in its larger size, the peripheral network of cells, the toxicity, and the distinctive odour and colour in decay.

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Le phytoplancton estival de la „Costa Brava" catalane en 1946

par Ramón Margalef (Barcelona).

Les resultats des croisières océanographiques danoises et de celles du Prince de Monaco, nous fournissent d'importants renseignements sur le phytoplancton de ce segment du littoral méditerranéen. Le matériel accumulé par le laboratoire Arago, de Banyuls-sur-mer, a été étudié par Dangeard (1932) dans un mémoire qu'on ne saurait trop estimer. Il peut être utile aussi au lecteur de savoir que les conditions hydrographiques de la côte catalane pendant l'hiver ont été étudiées par de Buen y Navarro (1935), et qu'on trouvera un résumé de tout ce qu'on sait sur la flore planctonique des eaux voisines des Baléares dans l'importante publication de Navarro y Bellon (1945).

Faute de laboratoire dans le littoral espagnol, où centrer de recherches suivies, nous avons profité du bienveillant secours de quelques amis, patrons de bateaux pêcheurs et autres, qui ont bien voulu nous recuellir un materiel précieux, que nous avons étudié dans deux travaux antérieurs, l'un sur le cycle annuel du phytoplancton à Blanes, l'autre sur le phytoplancton estival à Cadaqués. La dernière année nous avons eu à notre disposition des échantillons obligeamment communiqués par nos amis, Ms. Zariquiey (Cadaqués) et Balcells (Llafranc). Le petit croquis annexe (Figure 1) permet de se rendre compte de la localisation des stations d'étude dans le littoral catalan.

Il s'agit d'un plancton estival, des eaux superficielles, peu abondant, et dans lequel nous n'avons pas pu reconnaitre aucune espèce nouvelle pour la Méditerranée occidentale. Une donnée intéressante est que le changement autumnal-diminution de *Ceratium massiliense*, survenue des diatomées- s'est initié en 1946 de très bonne heure, dès les premiers jours de septembre, tandis que la date habituelle de ce tournant planctonique est mi-octobre. Dans tous les échantillons, le zooplancton était très abondant, la dominance absolue appartenant aux copépodes, un peu moins nombreux étaient les ptéropodes et les larves des crustacés; cladocères, larves de mollusques, *Sagitta* et tintinniens n'étaient pas rares du tout.

Composition des pêches.

Pêches horizontales dans les eaux superficielles. Presque toutes ont été faites l'après midi. 5=en masse, 4=très abondant, 3= abondant, 2=commun, 1=peu commun ou rare, +=très rare ou isolé.

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Localité / Distance de terre / Date	Llafranc 50—200 m. 15—VIII—46			Cadaqués 50—200 m. 28-VII-46	28-VII-46	24-VIII-46	26-VIII-46	28-VIII-46	30-VIII-46	25—35 Km. 3-IX-46			50— 24-
Dinoflagellata													
Prorocentrum micans Ehrenb.	.	.	.	1	1	.	+	.	.	+	.	+	.
Pyrocystis fusiformis Wyville Thompson	.	.	.	.	.	.	.	.	.	.	.	+	.
Phalacroma rotundatum (Clap. & Lachm.) Kof. & Mich.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phalacroma argus Stein	.	.	.	.	.	+	+	.	.	+	+	1	.
Phalacroma cuneus Schütt	.	.	.	.	.	.	.	.	.	.	.	.	.
Phalacroma doryphorum Stein	.	.	.	.	.	.	+	.	.	.	+	.	.
Dinophysis sphaerica (Stein) Schütt	.	.	.	.	.	+	.	.	.	.	.	.	.
Dinophysis Schroederi Pavillard	.	.	.	.	+	.	.	+	.	+	+	.	.
Dinophysis caudata Sav. Kent	.	.	.	.	.	+	+	.	.	.	1	.	.
Dinophysis tripos Gourret	.	.	.	.	+	.	.	.	.	+	+	.	.
Ornithocercus magnificus Stein	.	.	.	.	.	.	+	.	.	.	.	.	.
Amphisolenia bidentata Schröder	+	.	.	.	.	+	+	.	.	.	+	.	.
Gonyaulax polyedra Stein	.	.	+	+	.	.	1	.	.	1	+	.	.
Gonyaulax polygramma Stein	.	.	.	+	.	.	.	.	.	.	+	+	.
Gonyaulax sp	.	.	.	.	.	.	.	.	.	.	.	.	+
Peridinium diabolus Cleve	.	.	.	+	.	.	.	.	.	.	.	.	.
Peridinium cf. diabolus	.	.	.	.	.	1	+	.	.	.	.	.	.
Peridinium sphaeroides Dang. (P. globulus Stein)	.	.	.	.	+	.	+	+	.	1	1	1	+
Peridinium oviforme Dang.	.	.	.	.	.	+	+	.	.	+	1	.	.
Peridinium Steinii Jörg.	.	.	.	.	.	+	.	.	.	.	.	.	.
Peridinium Brochii Kofoid & Swezy	.	.	.	1	+	1	+	.	.	+	+	.	.
Peridinium crassipes Kofoid	.	.	.	+	.	2	1	1	.	1	1	1	.
Peridinium depressum Bailey	.	.	.	+	+	+	1	+	+	+	+	.	.
Peridinium oceanicum Vanhöffen	.	.	.	.	.	.	.	.	.	.	.	.	.
Peridinium subinerme Paulsen	.	.	.	.	.	.	+	+	.	.	.	.	.
Peridinium sp.	.	.	.	+	.	.	.	+	.	.	.	.	.
Peridiniopsis asymmetrica Mangin (Glenodinium lenticula (Bergh) Schiller fa. asymmetrica (Mangin) Schiller	.	.	.	.	.	.	+	.	.	.	+	.	+
Ceratium candelabrum (Ehrenb.) Stein var. dilatatum (Gourret) Jörg.	+	+	.	.	+	1	+	+	+	+	+	+	.
Ceratium furca (Ehrenb.) Duj.	+	.	+	2	1	1	1	.	+	.	1	.	+
Ceratium pentagonum Gourret	.	.	.	+	+	+	+	.	.	+	+	.	.
Ceratium strictum Kofoid	.	.	.	.	.	.	+	.	.	.	.	.	.
Ceratium longirostrum Gourret	.	.	.	+	.	+	.	.	.	.	+	.	.
Ceratium fusus Dujardin	+	+	.	1	+	+	1	.	.	+	+	.	+
Ceratium extensum Cleve	+	+	+	1	+	.	+	+	+	.	.	.	+
Ceratium tripos (O.F.M.) Nitzsch subsp. mediterraneum Pavillard	+	+	.	1	+	2	1	2	1	+	.	+	.
Ceratium declinatum Karsten	.	.	.	+	+	.	+	+	+	.	.	+	.
Ceratium Karsteni Pavillard	.	.	.	+	.	.	+	+	.	.	.	.	.
Ceratium concilians Jörgensen	.	.	.	.	.	+	+	+	.	.	+	.	+
Ceratium gibberum Gourret	.	.	.	+	+	+	+	.	.	.	.	.	+
Ceratium massiliense (Gourret) Karsten	2	1	.	4	2	2	1	.	2	+	1	+	.
Ceratium carriense Gourret	.	.	.	+	+	+	.	.	.	.	.	.	.
Ceratium carriense fa.	.	.	.	2	+	.	.	.	.	.	.	.	.

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Localité	Llafranc			Cadaqués										
Distance de terre	50—200 m.			50—200 m.						25—35 Km.				50—200 m.
Date	15—VIII—46			28-VII-46	28-VII-46	24-VIII-46	26-VIII-46	28-VIII-46	30 VIII-46	3-IX-46				24-IX-46
...a volans Cleve	+	+	.	.	1	.	.	.	.	.	.	.	.	.
...a contrarium Pavillard	+	+	.	.	+	.	.	.	.	.	+	+	+	.
...a trichoceros Kofoid	+	.	.	+	1	1	+	1	+	.	+	.	+	+
...a macroceros (Ehrenb.) Cle- subsp. gallicum (Kofoid)	.	.	.	+	1	1	+	1	+	.	+	.	+	+
...a hexacanthum Gourret	.	.	.	1	+	.	+	+	.	.	.	.	.	+
...ma polyedricum (Pouchet)	.	.	.	+	.	+	+	+	.	+	+	1	.	1
...ma polyedricum fa.	.	.	.	.	.	+	.	.	.	.	1	.	+	.
...ma sphaericum Murr. & ...tt.	.	.	.	1	.	+	1	.	.	+	.	+	+	.
...cus horologium Stein	.	.	.	.	.	+	+	.	.	+	.	.	.	.
...m scolopax Stein	.	.	.	.	.	.	+	.	.	.	.	.	.	.
...orys horrida Stein var. exten-...av.	.	.	.	.	.	+	+	+	.	+	.	.	+	+
...pas bipes Stein	.	.	.	.	.	+	1	.	.	+	.	.	.	.
...pas palmipes Stein	.	.	.	+	.	+	.	.	.	.	+	.	+	.
...pas spinifera Okamura	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Bacillariophyta														
...mpra marylandica Ehrenb.	.	.	.	.	.	+	+	.	.	+	.	.	.	.
...solen mediterraneus H. Péra-o	.	+	.	+	.	+	.	.	.	1	.	.	.	.
...indrus danicus Cleve	.	.	.	.	.	.	.	.	.	.	.	.	+	.
...ia flaccida (Castracane) Pé-llo	.	.	.	.	.	.	.	.	.	+	.	.	+	+
...enia Stolterfothii H. Péra-o	.	+	.	+	.	.	1	.	.	1	1	1	2	+
...enia hebetata Bailey var. ispina (Hensen) Gran.	.	.	.	+	+	.	.	.	.	.	.	.	+	1
...enia calcaravis M. Schultze	2	1	.	+	.	+	1	.	.	2	1	2	1	.
...enia alata Brigthwell fa. ge-a	.	+	.	.	.	.	.	.	.	.	.	+	.	.
...enia alata Brightwell fa. gra-na	+	.	.	1	.	.	.	.	.	2	2	2	2	.
...strum delicatulum Cleve	.	.	.	.	.	.	.	.	.	.	+	.	.	.
...eros densus Cleve	.	+	.	.	.	.	.	.	.	+	.	.	.	.
...eros rostratus Lauder	1	+	.	+	.	.	+	.	.	+	.	1	+	.
...eros decipiens Cleve	.	.	.	+	.	.	.	.	.	+	+	+	1	.
...eros compressus Lauder	.	.	.	.	.	.	.	.	.	+	.	+	+	.
...eros affinis Lauder var. Wil- (Gran) Hustedt	.	.	.	.	.	.	.	.	.	.	+	.	.	.
...eros sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
...ia pulchella Gray	.	.	.	+	.	.	.	.	.	.	.	.	.	.
...ina Bergoni H. Péragallo	.	.	.	+	.	.	.	.	.	.	.	+	.	.
...us Hauckii Grun	.	.	.	+	.	.	.	.	.	1	.	.	+	+
...us sinensis Greville	.	.	.	.	.	.	.	.	.	.	.	.	+	+
...tophora sp.	+	.	.	.	.	.	.	.	.	.	.	.	.	+
...ella mediterranea (Pavill.) galef	.	.	.	.	.	.	.	.	.	.	.	.	.	+
...ia sp.	.	.	.	+	.	.	.	+	.	.	.	.	.	.

Localité	Llafranc	Cadaqués							
Distance de terre	50—200 m.	50—200 m.						25—35 Km.	50—20
Date	15—VIII—46	28-VII-46	28-VII-46	24-VIII-46	26-VIII-46	28-VIII-46	30 VIII-46	3-IX-46	24-IX
Pleurosigma sp.	+ . .	.	+	+	.	.	.	. . . .	
Nitzschia longissima (Bréb.) Ralfs closterium (Ehrenb.) van Heurck	. . .	+	.	.	.	.	.	. . . .	
Nitzschia seriata Cleve	. . .	+	.	.	.	.	.	. . . .	
Heterocontae									
Halosphaera viridis Schmitz	. . .	.	.	+	.	+	.	. + + .	

Notes sur quelques espèces.

Le diamètre transversal est mesuré dans le centre du sillon. Le chiffre entre parenthèses donne le nombre d'individus mesurés.

Fig. 1.

Emplacement des stations d'étude dans la Costa Brava.

Peridinium diabolus Cleve—Diam, trans.: 39μ; long. $60+20$ μ (1) — Une autre forme, plus fréquente, est semblable à *diabolus*, mais l'apex est relativement moins allongé et les épines antiapicales sont un peu plus rapprochées à leur base; les dimensions sont plus petites: diam. trans.: 31 μ; long.: $(38—42) + 15$ μ (3). La tabulation n'a pas été étudiée.

Peridinium Brochii Kofoid & Swezy — Diam. trans.: $47—55$ μ; long. $70—80$ μ (5). La tabulation normale est du type metaquadra; mais nous avons vu un exemplaire ortho-quadra.

Peridinium crassipes Kofoid — (Fig. 2, 5—6) — Diam. trans.: $90—100$ μ; long.: $93—100$ μ.

Ceratium furca (Ehrenb.) Duj. — (Fig. 3, 1—2—3) La forme petite (1) est la plus fréquente et c'est la seule qui s'est presentée dans nos études antérieures. En 1946 nous avons vu quelques exemplaires plus grands et un peu différents (2—3); diam. trans: $37—40$ μ; apex/sillon: 170 μ sillon/antiapicale droite: $65—75$ μ; sillon/antiapicale gauche: $140—150$ μ (2).
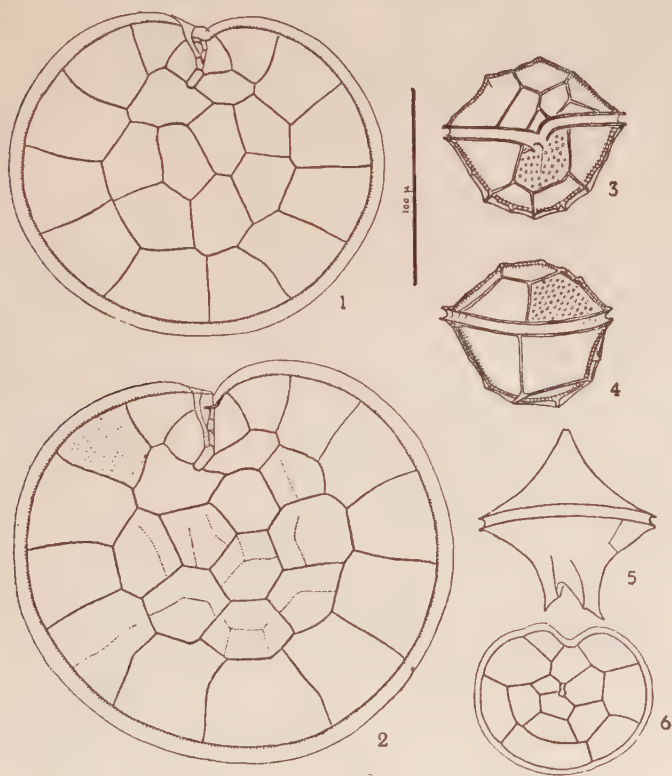

Fig. 2.

1, 2, **Pyrophacus horologium**, hypovalves de deux exemplaires. — 3, 4, **Goniodoma polyedricum**, forme plus grande que le type. — 5, 6. **Peridinium crassipes.**

Ceratium pentagonum Gourret — Il existe une gradation continue entre les types que nous avons figuré dans nos travaux antérieurs; le diamètre transversal de quelques spécimens descend jusqu' à 60 μ. Il n'est pas commode d'appliquer à ces diverses formes les noms de variétés qui ont été proposés.

Ceratium concilians Jörgensen — (Fig. 3, 4) — Diam. trans.: 85—91½ μ; envergure: 130—140 μ, (2), et *Ceratium gibberum* Gourret — (Fig. 3, 5—6) — Diam. trans.: 87—94 μ; enverg.:
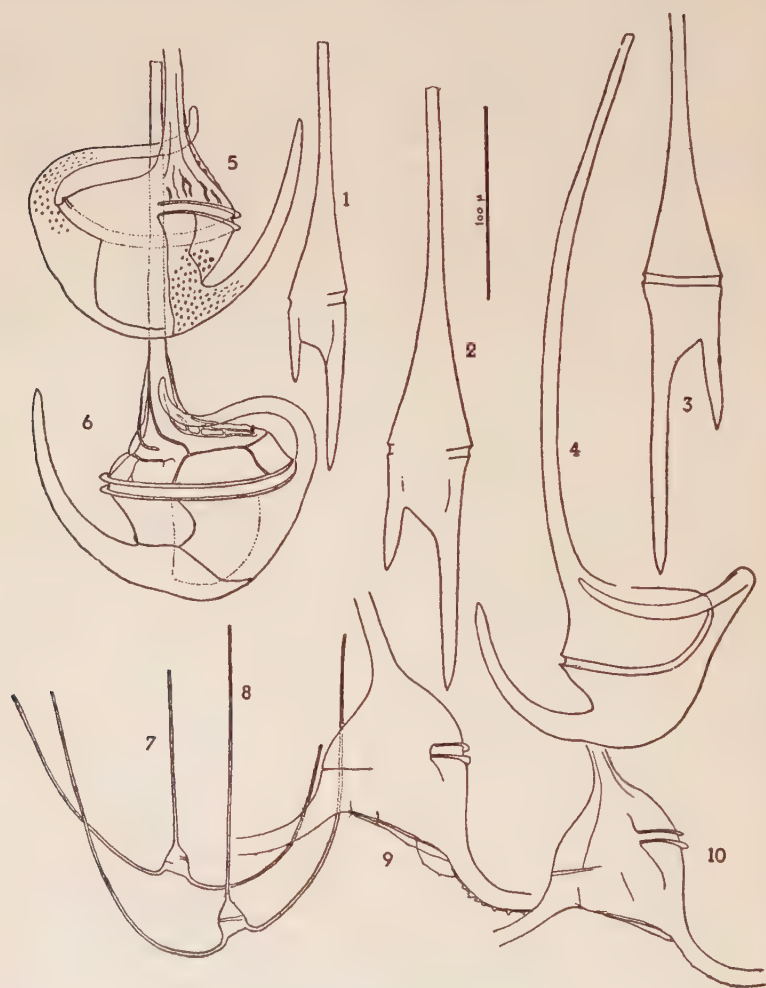

Fig. 3.

1, 2, 3, Différentes formes de **Ceratium furca.** — 4. **Ceratium concilians.** — 5, 6, **Ceratium gibberum.** — 7, 8, 9, **Ceratium carriense fa.** — 10, **Ceratium volans.** — Les figures 7 et 8 sont dessinées à une échelle différente de celle indiquée sur la gravure.

137—140 μ (3), peuvent être certainement séparés l'un de l'autre dans notre matériel.

Ceratium carriense Gourret — (Fig. 3, 7—8—9) — C'est par exception que nous avons recensé le type de cet espèce, qui est franchement hivernal. Moins exceptionelle était une forme dont la cellule est robuste comme dans le type, mais qui se rapproche de *volans* par la courbure des cornes antiapicales; diam. trans.: 75 μ; apex/sillon: 600—825 μ; envergure: (330—400) + (450—600) μ. Comparez avec la cellule du véritable *volans* (Fig. 3, 10).

Goniodoma polyedricum (Pouchet) Jörg. — (Fig. 2, 3—4) — La forme plus fréquemment trouvée est assez grande. diam. trans.: 58—70 μ, long.: 51—67 μ (5). On trouve melangés des exemplaires encore plus volumineux — diam. trans.: 81—90 μ, long.: 75—80 μ mais qui sont identiques au type par sa tabulation. On peut remarquer, cependant, que le sillon est un peu plus déplacé vers le pôle antérieur, de façon à diminuer la hauteur de l' épivalve.

Pyrophacus horologium Stein — (Fig. 2, 1—2) Section équatoriale de 175—200 × 150—183 μ. La tabulation est très variable; on peut remarquer dans les gros exemplaires que les plaques sont subdivisées sécondairement.

Bibliographie.

DANGEARD, P. 1932. Phytoplancton recuelli à Banyuls-sur-mer. **Archives de Zoologie expérimentale**, t. 74. no. 18.

DE BUEN, R., y NAVARRO, F. 1935. Condiciones oceanográficas de la costa catalana, entre la frontera francesa y el golfo de San Jorge. **Trab. del Inst. Espanol de Oceanografía, no. 14.**

HUSTEDT, F. 1930. Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz. **Dr. L. Rabenhorst's Kryptogemen-Flora,** Leipzig.

JOERGENSEN, E. 1920. Méditerranean Ceratia. **Report on the Danish oceanographical Expeditions 1908—10 to the Méditerranean and adjacent seas, II, Biology.**

MARGALEF, R. 1945. Fitoplancton nerítico de la Costa Brava catalana (sector de Blanes). **Instituto Espanol de Estudios Mediterráneos, Biol. no. 1, Barcelona.** = 1946. Fitoplancton nerítico estival de Cadaqués (Mediterráneo catalán). **Publ. Instit. Biol. Aplicada, t. 2, p. 89.**

NAVARRO, F., y BELLON, L. 1945. Catálogo de la flora del mar de Baleares. **Inst. Espanol de Oceanografía, notas y resúmenes, II. no. 124.**

PAVILLARD, J. 1931. Phytoplancton provenant des campagnes scientifiques du Prince Albert I de Monaco. **Résultats des camp. scientif. Prince Monaco, 82.** = 1937. Les Péridiniens et Diatomées pélagiques de la mer de Monaco de 1907 à 1914, observations générales et conclusions. **Bull de l'Inst. Océanographique Monaco, no. 738.**

SCHILLER, J. 1933—37. Dinoflagellata. **Dr. L. Rabenhorst's Kryptogamen-Flora,** Leipzig.

Algennachweis in Entenexkrementen

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Im äusserst strengen Winter 1946/47 lag der Spiegel des Pfäffikersees (Kt. Zürich) volle 3 Monate ununterbrochen unter Eisverschluss. Der Mangel offenen Wassers versetzte die Wasservögel in eine eigentliche Notlage. Während Haubentaucher und Blässhuhn nach dem Zufrieren des Sees die Gegend verliessen, verblieben Stock- und Zwergente (Krickente) an ihrem gewohnten Orte; ja es schien als ob sich ihre Zahl durch Zuzug noch vermehrt hätte. Die Standvögel pflegten tagsüber an bestimmten Stellen des Eispanzers regungslos zu verharren. In der Schlafstellung war der Körper der Tiere leicht niedergekauert, der Hals eingezogen und nicht selten der Kopf ins Rückengefieder „eingenestelt". Ende Januar und anfangs Februar, als der See von Schlittschuhläufern und Spaziergängern ziemlich belebt war, hatten die Tiere ihre Ruheplätze in der SE-Bucht N der Kemptnerbacheinmündung aufgeschlagen. Als später, zufolge Schneefall, der Besuch des Menschen fast ganz aufgehört hatte, rasteten die Schwimmvögel in grösserer Entfernung vom Ufer an einer den See überquerenden Eisspalte. Bei meinem Besuche am 23. Febr. schätzte ich die Zahl der versammelten Tiere auf ungefähr 400 Stück. Mit der Zeit hatten sich die Wildenten etwas an das Treiben des Menschen gewöhnt und es schien als ob sie furchtloser geworden wären. Man konnte auf ca. 80 m Entfernung an sie herankommen oder in dieser Distanz vorbeimarschieren, ohne dass die Tiere sich angeschickt hätten, das Weite zu suchen. Steuerte man aber direkt auf die schlafbetrunkenen Gestalten los, so kam Leben in ihre Leiber; Hälse begannen sich emporzurecken, ein kurzes Trippeln und dann das Starten in die Lüfte. Gewöhnlich dauerte der Flug der in bestimmter Formation zusammengeschlossenen Vögel nicht lange; nach einer Strecke von etwa 100 Metern liessen sie sich in der Regel wieder nieder und setzten dann ihre Tagruhe fort, wenn sie nicht durch eine neue Bedrohung abermals zum Weichen gezwungen wurden.

Die Enten pflegen mit Vorliebe in der Dämmerung ihre Nährreviere aufzusuchen. Zu diesen gehören im Gebiete der Kemtnerbach und die ihn begleitenden Wässerwiesen, die Zuflussgräben des Sees, der ihn entwässernde Aa-Kanal und der von diesem durchflossene Hellsee, zahlreiche wasserhaltende und pflanzenreiche Torfstiche des Verlandungsbodens.

Zur Zeit der Monatswende Januar-Februar gab es in der Seeumgebung da und dor Aperstellen, auf denen die nahrungssuchenden Tiere äsen konnten. Neue Schneefälle und anhaltender Frost engtn dann den Nährstoffbereich mehr und mehr ein. Schliesslich blieb als einzige Versorgungsquelle brachten es mit sich, dass die hungernden Vögel teilweise auch am Tage das Nährgebiet an der Aa aufzusuchen begannen. Mit der Zeit bildete sich zwischen den Schlafplätzen auf dem Eise und dem offenen Wasser des Seeabflusses ein regelrechter Pendelverkehr aus. Bei diesen über die Tagstunden erfolgenden Verproviantierungsflügen setzten sich jeweils nur kleinere Trupps in Bewegung, während das Gros zurückblieb und offenbar die der Gewohnheit entsprechende Zeit der Dämmerung oder der Dunkelheit abwartete. Das Hinüberwechseln der Tiere vom Rastort zur Nährstoffquelle auch am hellen Tage war des weiteren deshalb möglich geworden, weil zufolge reichlichen Schneefalls der Eissport auf dem See nachgelassen und das in den letzten Jahren üblich gewordene Schilfschneiden an den Ufern von See und Abfluss aufgehört hatte.

Wenn man die Ruheplätze der aufgescheuchten Vögel inspizierte, so gewahrte man als zurückgebliebene Spuren die unauffälligeren Zehenabdrücke im Schnee und die mit der weissen Unterlage stärker kontrastierenden Kotmassen der Tiere. Da für gewöhnlich die Exkremente wild lebender Tiere der Beobachtung entzogen bleiben, ergab es sich fast von selbst, dass ich mir die seltene Gelegenheit zur Abklärung gewisser Fragen nicht entgehen lassen wollte. Im ganzen trug ich 6 Proben ein, 4 (I—IV) am 3. Febr. und 2 weitere (V—VI) am 22. Febr. Der von den Tieren zurückgelassene Kot repräsentierte sich teils geformt und kompakt, wobei Kotsäulen bis zu 1,8 cm Durchmesser und 4 cm Länge festgestellt werden konnten, teils in mehr breiiger Form. In der Farbe variierten die Fäzes innert gewisser Grenzen, wobei ein moor-bis schokoladebrauner Ton vorherrschte. Die Kotballen von Probe,nummer III hatten nach Struktur und Konsistenz gewisse Aehnlichkeit mit Torfmull. In zwei Fällen (namentlich II) waren die Dejekte fleckenweise grünspanartig verfärbt, in zwei weiteren Fällen (V, VI) zufolge Untermischung mit Mineralstoffen grau-weiss panaschiert. Der frische Mist war noch weich, der stunden- oder tagealte dagegen steinhart gefroren. In jedem Falle zeichneten sich die körperlichen Ausstossungen durch einen ganz spezifischen, leicht stechenden, aber nicht unangenehmen Geruch aus, der in keiner Weise an den fäkalen Geruch etwa des menschlichen Stuhls erinnerte. Möglicherweise rührte er teilweise von beigemischten Exkreten, eventuell auch Sekreten her. Die gesammelten und unter Verschluss gebrachten Exkremente erwiesen sich als recht konservierungsfähig. Selbst nach tagelangem Verschluss in Glastuben konnte keinerlei Veränderng festgestellt werden. Mein Hauptaugenmerk richtete ich auf die

mikroskopische Analyse des Sammelgutes. Es interessierte mich vor allem die botanische Zusammensetzung der Nahrungsrückstände, insbesondere ein eventuelles Vorhandensein von Algen. Positiv ausfallende Ermitlungen sollten mir dazu dienen, Rückschlüsse auf die der Ernährung dienenden Gewächse und die ihnen zugehörigen Lebensbezirke (Biotope) zu ziehen. Ergänzend und der allgemeinen Orientierung dienend sei vorausgeschickt, dass die Vögel im allgemeinen gut verdauen, einen sehr lebhaften Stoffwechsel besitzen und dass die Durchgangszeiten durch den Darmkanal bei den Vögeln im Vergleich zu andern Tieren kurz sind und oft nicht mehr als eine Viertelstunde betragen.

Zum Zwecke der Probendurchsicht wurden kleinere Stücke vom Material durch Schlämmen auf den notwendigen Zerteilungsgrad gebracht und dann in einem Trophen Wasser auf dem Objektträger unter gelegentlichem Zusatz eines Aufhellungsmittels bei stärkerer oder schwächerer Vergrösserung untersucht. Im folgenden seien die Aanalysenergebnisse der einzelnen Proben in Kürze zusammengestellt:

Probe I

1. Fragmente von Gewebsstrukturen höherer Pflanzen (wenig zahleich), 2. Leere Frusteln der Kieselalgen: Synedra ulna var. notata, Cocconeis pediculus, C. placentula, Navicula gracilis, Gomphonema angustatum, 3. Ein lebender Ciliat (Wimpertierchen), 4. Schuppe eines Schmetterlingsflügels. Pro Präparat wurden durchschnittlich 2—3 Algen beobachtet.

Probe II

1. Fetthäufchen ähnliche Aggregate rundlicher Körperchen mit stärkerer Lichtbrechung und körnigem Inhalt, die in ihrer Gesamtheit die grünlichen Flecken an den Kotballen dieser Probe hervorriefen. 2. Isolierte Schraubenbänder von Spiralgefässen.

Probe III

1. Zahlreiche Gewebstrümmer höherer Pflanzen, 2. Bruchstücke und vereinzelte ganze Blätter des Laubmooses Plagiothecium latebricola, 3. Oberhautzellen von Sauergräsern.

Probe IV

1. Fragmente von Gewebsstrukturen pflanzlicher Herkunft, 2. Oberhautzellen eines Sauergrases, 3. Wurzelhaare, 4. Mehrzelliges und verzweigtes Pflanzenhaar.

Probe V

1. Zahlreiche Mineralstoffsplitterchen, die beim Zufügen von HCl kein Aufbrausen zeigten, 2. Zahlreiche Bruchstücke pflanzlicher Gewebe, 3. Fragmente verschiedener fädiger Grünalgen, so von zwei Oedogonium-Arten, einer Schraubenbandalge, von Microspora quadrata und namentlich häufig von Tribonema vulgare, 4. Ein 4-zelliges Coenobium (C. = bestimmt gestalteter kolonialartiger Verband, der durch Zusammenlegung kleiner, einzelliger Individuen entstanden ist) von Scenedesmus ecornis, 5. Staurastrum cingulum var. obesum, 6. Frusteln fol-

gender Kieselalgen: Fragilaria capucina, Synedra ulna, Navicula radiosa, Cymbella cymbiformis und Epithemia zebra var. porcellus, 7. Chitinpanzerstücke von Insekten.

Probe VI

1. Diverse nicht näher bestimmbare Gewebsbestandteile höherer Pflanzen, 2. zweizelliges Pflanzenhaar, 3. Schraubenband eines Spiralgefässes, 4. Mineralstoffsplitterchen.

Diese Bestimmungen gestatten es dem Fachkundigen ohne grosse Schwierigkeit in drei Fällen mit einer gewissen Bestimmtheit die in Frage kommenden Nährreviere unserer Vögel anzugeben. Das Algeninventar von Probenummer I deutet darauf hin, dass die Nahrung in diesem Falle in einem rascher fliessenden Gewässer, also in den Zuflussgräben oder in obern Teilen des Kemptnerbaches geholt worden ist; denn die meisten der verzeichneten Algen zählen zu den typischen Bach-oder Rheophilalgen. Für die Provenienz der Organismenstrukturen in Probenummer III liefert das Laubmoos die besten Anhaltspunkte; auch die torfmullähnliche Beschaffenheit der Probe vermag uns gewisse Hinweise zu geben. Plagiothecium latebricola wächst ausserhalb des Wassers an etwas schattigen Orten, gern unter oder in der Nähe von Erlen, auf Farnstöcken usw. In diesem Falle müssen die Vögel ihr Futter am Lande geholt haben. Zur Zeit des 3. Febr. hatte es tatsächlich da und dort im Verlandungsgürtel Aperstellen, auf denen die in ihrer Ernährungslage bedrängten Tiese äsen konnten. Bezeichnenderweise fehlen im Befunde dieser Probe jegliche Angaben über Algen. Schliesslich bestehen auch keine Zweifel über die Herkunft des Materials von Probe Nr. V. Die in dem Material nachgewiesenen Algen sind diesmal (ausgenommen die sehr anpassungsfähige Synedra ulna) keine typischen Bachformen. Soviel über ihre Oekologie bekannt ist, handelt es sich um Formen, die in stehenden oder langsam fliessenden Gewässern und in einem alkalischen Milieu zu leben pflegen. Eine besondere Beweiskraft kommt dann noch dem Staurastrum cingulum var. obesum zu. Diese Alge (alias St. gracile) gehört zu den prominentesten Vertretern des Pfäffikerseeplanktons. Nur im See und im ausmündenden Aakanal ist sie in der Gegend anzutreffen. Wegen der totalen Vereisung des Sees zur fraglichen Zeit konnte das Staurastrum unmöglich von der Seeseite her in den Entenmagen gelangt sein und so verbleibt als Herkunftsmöglichkeit nur noch der offen gebliebene Aakanal übrig. Diese von mir vertretene Ansicht wird ausser der bereits gegebenen Begründung, wobei nochmals auf den beobachteten regen Verkehr der Enten zwischen See und Kanal hingewiesen sein möge, noch durch die Tatsache gestützt, dass in einigen am 28. Febr. dem Kanal entnommenen Sammelproben sämtliche in der Mistprobe Nr. V ermittelten Algen enthalten waren. Mit der Häufigkeit des Tribonema in den Exkrementen korrespondierte eine Massenentwicklung zweier Tribonema-Arten in der „Kanalprobe".

Bei der Auswertung der Untersuchungsergebnisse, wie dies in dem gegebenen Beispiel gezeigt worden ist, muss mit grösster Vorsicht ans Werk gegangen werden. Sehr oft sind die Indikatoren, auf die man abstellt, zahlenmässig spärlich vertreten und in der Bedeutung nicht eindeutig. Es muss schon als glückhaften Zufall bezeichnet werden, wenn dem Untersuchenden ökologisch hochspezialisierte Typen zur Verfügung stehen, die an sich schon genügend Beweiskraft besitzen. Ausserdem ist bei der Präparationstechnik peinlichste Sorgfalt geboten, damit keine Verunreinigung des Materials stattfindet und im Zusammenhange damit Irrtümer und Fehlschlüsse unterlaufen.

Abbildungen der Algen und weiterer Organismennachweise in den untersuchten Entenexkrementen.

Fig.   1   Fragilaria capucina (Kapuziner Brechband)
,,   2   Synedra ulna (Ellenstäbchen)
,,   3   Navicula radiosa (Strahlen-Schiffchenalge)
,,   4   Navicula gracilis (schlanke Schiffchenalge)
,,   5   Gomphonema angustatum (verschmälerte Stielalge)
,,   6   Cymbella cymbiformis (echtes Cymbelchen)
,,   7   Epithemia zebra var. porcellus (getigerte Spannalge)
,,   8   Scenedesmus ecornis (ungehörntes Zackenband)
,,   9   Microspora quadrata (quadratzelliger Wasserfaden)
,,   10   Oedogonium spec. (Schwärmeralge)
,,   11   Tribonema (Conferva) vulgare (gemeiner Wasserfaden)
,,   12   Spirogyra spec. (Schraubenalge)
,,   13   Staurastrum cingulum var. obesum (umgürteter Kreuzstern)
,,   14   Laubblatt von Plagiothecium latebricola (schattenbewohnendes Krummkapselmoos)
,,   15   Oberhautzellen eines Sauergrases
,,   16   Stück pflanzlichen Gewebes
,,   17   Gefäss (Trachee)
,,   18   Isoliertes Schraubenband eines Gefässes
,,   19   Schuppe eines Schmetterlingsflügels
,,   20   Chitinröhrenglied einer Insektenextremität
,,   21   Kiefer einer Wasserinsektenlarve (oder Kralle?)
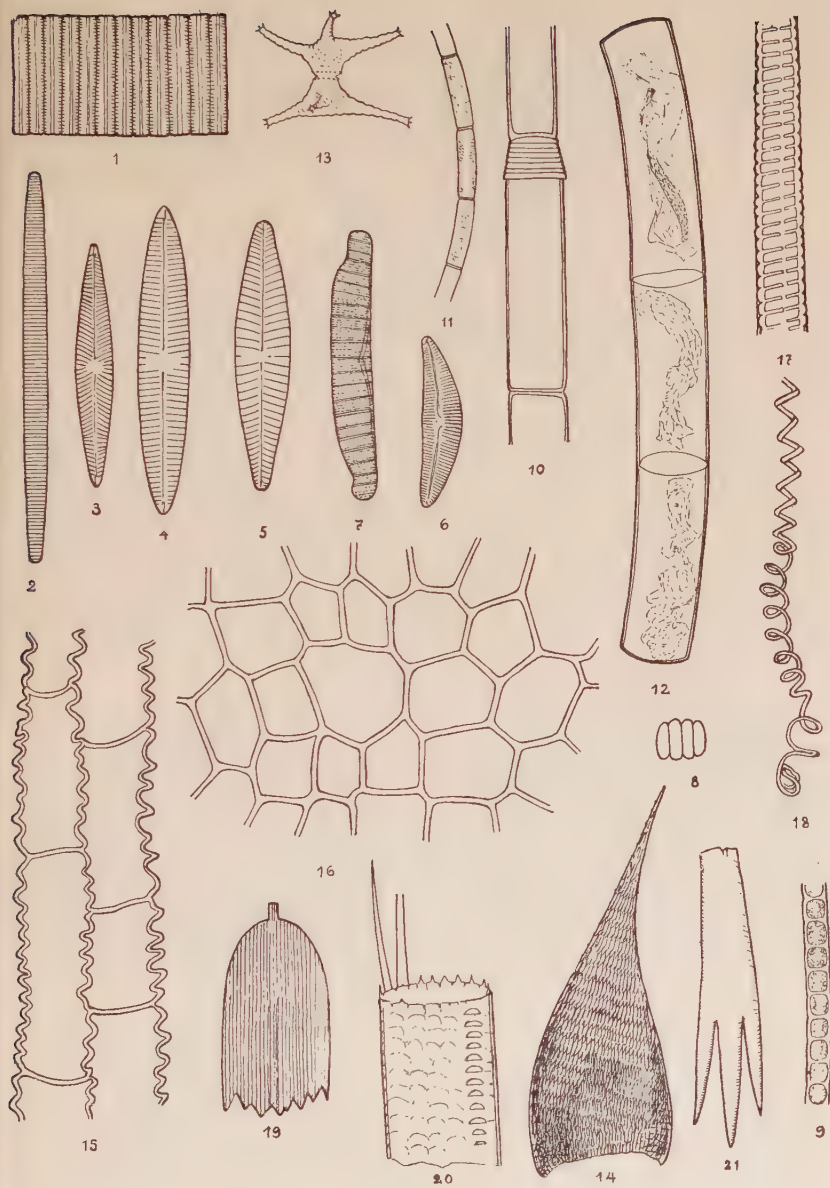
Thecamoebous Moss-rhizopods from New Zealand

By H. R. Hoogenraad and A. A. de Groot
(Deventer, Holland).

I. Introduction.

Some years ago we investigated the Thecamoebous Rhizopods in a number of dried moss samples obtained by purchase from several localities in Europe. The results of this investigation, partly unpublished yet, were relatively satisfactory and induced us (in 1938/'39) to treat some moss samples from outside Europe in the same manner. They were collected in New Zealand (19), Siberia (8), China (1), Africa (1), South America (11) and North America (17), in all 57 localities. Some of the samples proved rather rich in remains of Rhizopods; these we studied more thoroughly and determined the relative frequency of the different species occurring in it. This frequency we expressed in numbers varying from 1 to 6, 1 meaning very rare, 6 very common. Of the other samples we observed only a few preparations and noted the species, occurring in it, which were also entered in the general survey of the species.

The samples studied belonged for a very small part to the *Sphagnales*, for far the greater part to the *Bryales*. They were collected with bryological, not with zoological purposes, and consequently from the Rhizopodan tests occurring in the dry samples a conclusion as to the species which lived in the mosses in a fresh condition cannot be drawn with any degree of certainty. It is possible that especially *Sphagnum* species growing in very wet places were squeezed out by the collector to remove the redundant water; obviously in such a case a more or less greater number of the tests were also removed.

On the other hand, the tests actually present in the samples were in the whole preserved in an excellent condition, notwithstanding the fact that the greater part had been collected many years ago and had since been kept in a dry state. This applies not only to the species the tests of which are composed of xenosomes, but also to those the tests of which existed of idiosomes or presented a hyaline structure.

The manipulation of the material was relatively simple. For a short time it was boiled up in water to remove the adhering air, after cooling pressed out with the hand and the sediment studied in ordinary cover-glass preparations; permanent-prepa-

rations were enclosed in glycerin-gelatin. The frequency numbers were determined according to a fixed method by counting all the individuals occurring in a definite number of preparations.

In this first part of our work we will publish the results of the examination of the material collected in New Zealand; we intend to treat in following articles the material from the other localities mentioned in the same manner. Finally we shall give some general remarks regarding the material as a whole in the concluding article.

II. Analysis of the samples.

1. *Rhacopilum strumiferum* (C. MÜLL.) JAEG.; Lyttelton; collected 1874, investigated 1938.

Centropyxis aerophila DEFL.	1
„ *?ecornis* (EHRBG.) LEIDY	2
„ *?orbiculare* DEFL.	1
Difflugia lucida PEN.	1
„ spec.	1
?Phryganella spec.	1
Nebela vas CERTES	1
Assulina muscorum GREEFF	1
Euglypha ciliata LEIDY	4
„ *?rotunda* WAILES	1
Trinema enchelys (EHRBG.) LEIDY	1

Centropyxis ?ecornis (Fig. 1, 2).
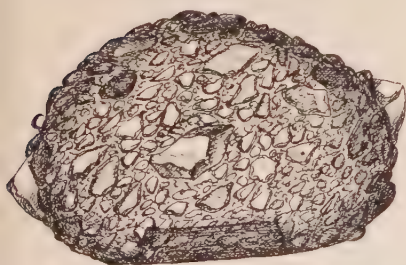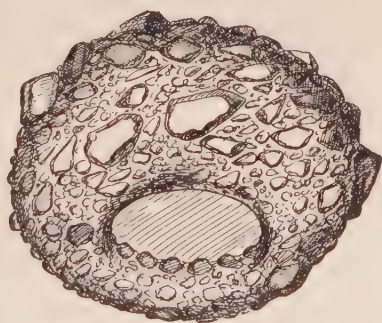

Fig. 1   Fig. 2

Test dark brown, with numerous quartz grains, as seen from above rather circular, from aside distinctly compressed, more or less semi-globular. Aperture round, often placed slightly eccentrically, sometimes with a series of big quartz grains along the margin, and hence this more or less crenulated. No spines. The ground structure of the test distinctly centropyxoid, otherwise this species might be taken for a form of *Difflugia globulosa*.

Dimensions: long 124-190, high 100-125, aperture 50-70 μ.

Fig. 3   Fig. 4

Difflugia lucida (Fig. 3).

Some typical individuals of this species, largely distributed in southern localities.

Dimensions: long 60—70, broad 30—50, aperture 23—33 μ.

Difflugia spec. (Fig. 4).

Next to *D. lucida* in this sample another species of *Difflugia* occurred in a few individuals, resembling *lucida* in a high degree, but bigger and less compressed, the outline more pearshaped in consequence of the somewhat narrowed neck part of the test.

Dimensions: long 97—113, broad 53—60 μ.

Nebela vas.

Only two individuals of this typical southern species.

Dimensions: long 120 and 123, broad 88 and 77 μ; neck long 33 and 33, broad at the basis 43 and 40, at the aperture 30 and 27 μ.

Trinema enchelys.

Two individuals, the one long 80, broad 47, with, the other long 77, broad 33 μ, without „galea".

2. *Ptychomnium aciculare* (BRID.) MITT.; Bealey; collected 1874, investigated 1939.

Centropyxis constricta (EHRBG.) PEN.	2
„ spec.	1
Trigonopyxis arcula (LEIDY) PEN.	3
Difflugia lucida PEN.	1
Heleopera spec. a	1
„ spec. b	1
Hyalosphenia subflava CASH	1
Nebela ?certesi PEN	1
„ *cockayni* (PEN.) WAILES	2
„ *martiali* CERTES	3
„ *militaris* PEN.	1
„ *tubulata* BROWN	1

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„ *vas* CERTES	4
„ spec.	1
Phryganella hemisphaerica PEN. spec.	1
Euglypha acanthophora (EHRBG.) PERTY	1
„ *ciliata* LEIDY	2
„ *?compressa* CARTER	1
Assulina muscorum GREEFF	3
Corythion dubium TARAN	1
Trinema complanatum PEN.	1
„ *lineare* PEN.	1

Trigonopyxis arcula.

A moderately numerous population; individuals small varying only little in structure and dimensions.
Dimensions: 76—103 μ.

Heleopera spec a and b.

Neither of the two forms of this genus occurring in the sample could be identified with sufficient certainty with one of the exactly described and clearly recognizable species. Only a few individuals were observed; they differed from each other mainly by the shape, the colour and the dimensions of the test: a big one, yellowish, long $\pm$ 120, broad $\pm$ 100 μ, another smaller, colourless, long $\pm$ 75, broad $\pm$ 50 μ. The fundus part of the test of both forms was closely covered with xenosomes.

Nebela ?certesi.

This form of the genus *Nebela* differed from the typical *certesi* by the less distinct development of the longitudinal neck groove. Test always colourless; frontal pores rather distinct, lateral ones dubious.
Dimensions: long 123—153, broad 70—97 μ.

Nebela cockayni [1]) (Fig. 5—8).

This southern species of the genus *Nebela*, originally described by PENARD in the Results of the British Antarctic Expedition 1911 as *Hyalospenia cockayni*, is mentioned bij him as coming only from the Auckland Island, New Zealand (1 individual) and Australia (very scarce). WAILES (1913) detected it at Punta Arenas (Tierra del Fuego); later on it seems not to have been observed by anyone. In our material from New Zealand it occurred only in this sample, however, in a rather numerous population.

The most obvious characteristic of the test of this species is a rather deep cross contraction at some distance above the aperture. At a rather large number of individuals in the sample

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1) As the name of this species is derived from the name COCKAYNE of the well known New Zealandian naturalist, the right spelling of it should be: cockaynei.

Fig. 5

Fig. 6
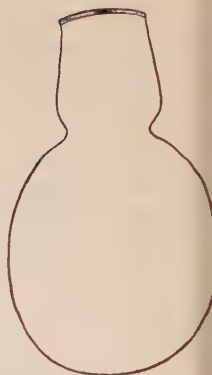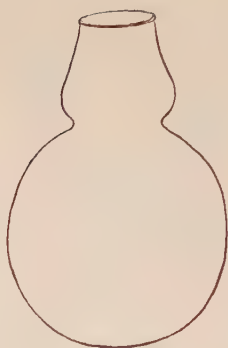
Fig. 7
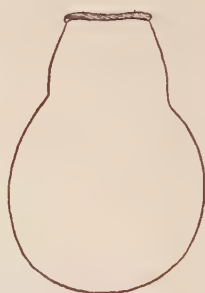
Fig. 8

this contraction was distinctly developed; we believe that these individuals represented the typical form of the species. They were coloured faintly yellow, showed a finely facetted pattern, almost exactly corresponding with the so-called nebeloid structure. Bigger elements were always absent. On account of this structure WAILES and DEFLANDRE rightly unite this species with the genus *Nebela*. PENARD also alludes to this possibility and moreover mentions the occurrence of xenosomes, viz. *Euglypha* scales, among the elements of the test, such as are also present in the tests of other *Nebela* species, e.g. *N. vas*. Therefore we cannot understand why PENARD describes this species after all as appertaining to the genus *Hyalosphenia*, because the tests of all the species of this genus are always hyaline and show never the nebeloid structure. PENARD moreover mentions the existence of lateral pores between the contracted part of the test and the aperture, which, however, according to him may be absent sometimes; we ourselves have never detected any pores in the test.

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The test of *N. cockayni* is moderately compressed, the cross section being broad-elliptical.

The individuals of the Auckland Island were long 50—100 broad 45—55 μ; the only individual from New Zealand long 115, those from Australia 100 μ. WAILES mentions for material from South America (Tierra del Fuego) a lengt from 120 to 126, a breadth from 74 to 75 μ. In our material the length varied from 110 to 127, the breadth from 70 to 80 μ; it also corresponded in respect with the dimensions with that of WAILES. The length-breadth index seems in general to be as 2 : 3; only the Auckland population of PENARD was narrower. Taking 95 μ as mean length and 50 μ as mean breadth, one obtains a mean breadth-index of 53 %.

Besides the form described above two aberrant forms occurred in our material. Of the first the dimensions and the breadth-index were the same as in the type, the cross contraction of the test, however, much less indicated, but developed in varying grades of reduction. It is not impossible that a form in which the contraction lacked completely, but which for the rest was exactly like the type, represented an extreme term of the whole range of variation.

The other variant distinguished itself from the former by its dimensions, the contraction of the test, however, as distinctly developed as in the type. The length of this form varied from 140—160, the breadth from 93—107 μ. Besides there occurred differences in structure and colour; in the first variant the colour was that of the type, in the second one it was much darker yellow. This second form appeared to us as completely autonomous and not related to the type by transitory forms.

Nebela martiali (Fig. 9—11).

The rather rich population of this species showed also some remarkable peculiarities. A number of them exhibited the habitus already known to us from other localities, which in our opinion represented the type. In the greater part of them the test seemed to be of a more or less membranaceous structure with a more or less dark reddish hue; test of such nature we also observed later on in material from Tierra del Fuego. Especially in these darker coloured individuals the colourless frontal pores contrasted sharply with the ground colour of the test.

From this form some individuals differed by the more yellowish tinge of the test and also by the more gradual transition of the broader fundus into the narrower neck part. Other, usually very dark red coloured, tests possessed a much narrower neck part than the above mentioned ones and bore the conspicuous lateral pores on the top of nipple-formed projections of the neck. The development of the frontal pores in the three forms was almost the same.

DEFLANDRE (1936) indicates as limits of the dimensions of
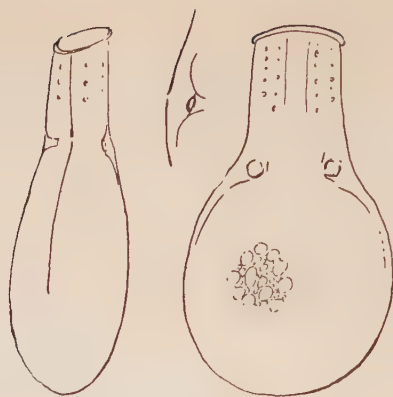
Fig. 9

Fig. 10
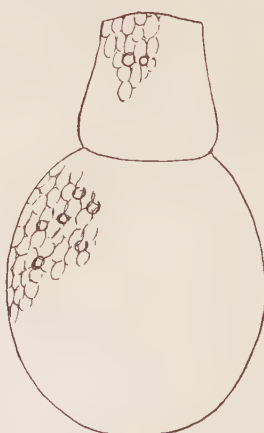
Fig. 11   Fig. 12

a number of individuals of this species from Australia and South America: length 155—170, breadth 85—91 μ. A single individual in our possession from South America (Expedition FUHRMANN) is long 190, broad 123 μ. It therefore seems that the population from New Zealand here described considerably exceeds in size all those formerly known. Whether the three different forms of our material are statistically distinguishable by their dimensions, we could not make out with sufficient certainty, but is seemed to us that the biggest individuals belonged to the first, the smallest ones to the second variant, while those of medium size represented the type.

Dimensions: long 147—233, broad 77—130 μ.

Nebela vas (Fig. 12).

A rather normal population of this species.
Dimensions: long 151—160, broad 99—105 μ.

3. *Echinodium hispidum* (HOOK. fils et WILS.) JAEG.; Lyttelton; collected 1875, investigated 1939.

Centropyxis constricta (EHRBG.) PEN	5
„ spec.	5
Difflugia lucida PEN.	2
Heleopera petricola LEIDY var. *amethystea* PEN.	1
Heleopera ?sordida PEN.	1
Nebela lageniformis PEN.	3
„ *?lageniformis* PEN.	2
„ *vas* CERTES	2
Phryganella hemisphaerica PEN. spec.	2
Euglypha ?ciliata LEIDY	2
Assulina muscorum GREEFF	3
Corythion dubium TARAN.	1
Trinema complanatum PEN.	1
„ *lineare* PEN.	1

Difflugia lucida.

A small, but as far as we could see, typical population of this species.
Dimensions: long 53—67, broad 30—40 μ.

Heleopera ?sordida.

The sample contained a small number of individuals of a minor, completely colourless species of *Heleopera*, with distinctly developed, sometimes a little yellowish coloured rim bordering the aperture, but only a few xenosomes on the fundus top. Although in structure of the test in some degree different from this species, it agreed in other respects chiefly with *H. sordida*, and belonged to the forms of this genus which one so frequently

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meets in *Sphagnum* and other mosses, but which are in consequence of a peculiar combination of characteristics difficult to analyze and could practically not be determined with sufficient probability.

Dimensions: long 73—80, broad 47—63 μ.

Nebela lageniformis.

This species, widely distributed als over the southern hemisphere, but by no means confined to it, occurred in the sample in a number of individuals which could be easily determined. On the whole the population showed the same characteristics as that of sample 4 (see p. 39) Size and structure of the test varied only little, the latter being distinctly nebeloid. The greatest differences occurred in the mode of transition of the fundus in the neck part, in this sense, that the transition was in some cases rather gradual, in otherones more abrupt; in the latter case the neck was very distinctly thrown into relief.

Dimensions: long 100—123, broad 58—73 μ; neck long 27—37, broad 23—33 μ.

Together with this form another one occurred, indicated as *?lageniformis*, concording in dimensions with the type, but distinguished from it by soms particularities of structure. As only a few defect individuals of this form were observed, we cannot give any further information about it.

Nebela vas.

Only a few individuals, typical, with exception of the fundus part, this being narrower than usual and therefore giving the test a more oblong elliptical shape. In some specimens we observed between the xenosomes of the neck some *Euglypha* plates, which also occur in the tests of some other species of this genus.

Dimensions: long 113—120, broad 63—73 μ; neck long 30—38, broad (in mean) 30—37 μ.

4. *Rhacocarpus australis* (HAMPE) PAR.; Bealey; collected 1874, investigated 1938/'39.

Arcella artocrea PEN	1
„ *hemisphaerica* PERTY	1
Centropyxis constricta (EHRBG.) PEN.	1
„ *discoidea* (PEN.) DEFL.	1
Trigonopyxis arcula (LEIDY) PEN.	1
„ *microstoma* nov. spec.	4
Difflugia spec.	1
Nebela certesi PEN.	2
„ *?dentistoma* PEN.	1
„ *lageniformis* PEN.	3
„ *?militaris* PEN.	1

Nebela penardiana DEFL.	1
„ *tubulata* BROWN	1
„ *vas* CERTES	6
Euglypha ?strigosa (EHRBG.) LEIDY	2
„ spec.	3
Placocysta spinosa (CARTER) LEIDY	1
Assulina muscorum GREEFF	2
„ *seminulum* PEN.	1
Corythion dubium TARAN.	1
Trinema complanatum PEN.	1
„ *enchelys* (EHRBG.) LEIDY	1
„ *lineare* PEN.	4

Arcella artocrea.

The dark brown *Arcella* species of this sample, only present in a few specimens, showed the structure as well as the size of the typical *artocrea* of PENARD. The outline of the test was either exactly circular, or broad-elliptical, the aperture being always elliptical, surrounded by a circle of ± 20 large pores. —

Trigonopyxis microstoma nov. spec. (Fig. 13, 14).

In a rather considerable number of individuals the sample contained an object we believe to be the test of a hitherto unknown species of Rhizopods; afterwards we discovered the same object again in moss samples from Tierra del Fuego in a nearly identical form. Shape and structure of the object in general as well as the general features of the aperture reminded us so strongly of those of *Trigonopyxis arcula*, that under reserve of possible later corrections we consider this form to be an as yet unknown species of the above named genus *Trigonopyxis* PE-
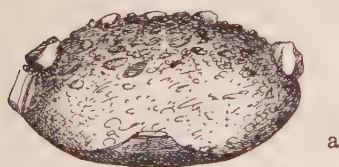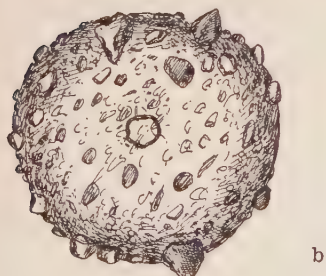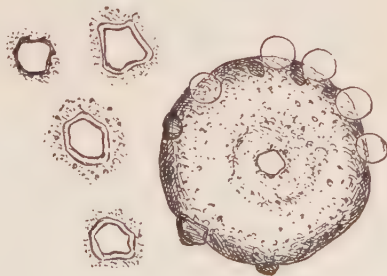

Fig. 13

Fig. 14

NARD. Some delicate characteristics of structure, but especially the different form and much smaller dimensions of the aperture are sufficient to distinguish it from the hitherto only known species of the genus: *T. arcula* (LEIDY) PEN. (= *Difflugia arcula* LEIDY). On the ground of the most salient feature of the test., viz. the small aperture, we provisionally propose for the species the name: *Trigonopyxis microstoma*.

Seen from above, i.e. in the direction of the oral-aboral axis, the test is nearly always exactly circular in outline, sometimes, however, slightly elliptical; seen from aside the test appeared as a rather strongly compressed spheroid, with a heigth of almost half the diameter of the test. The oral plane was usually less flattened than the fundal one; the aperture more or less deeply, sometimes, however, hardly, invaginated. The colour varied from yellowish to rather dark brown. The fundal part was covered with xenosomes of all sorts, mainly larger and smaller quartz grains and variegated sapropelium particles, sometimes projecting far beyond the outline of the test; among them often projecting almost completely beyond the circumference some circular, colourless corpuscles of 10—15 μ diameter, such as are also often observed in the test-covering of other Rhizopods, especially in species of the genus *Amphitrema;* probably they represent the empty cell walls of certain unicellular Algae. Never were Diatomaceae tests observed among the test elements; they also failed in the sample itself. By way of exception, the sapropelium particles also failed entirely and the covering existed only in a dense collection of quartz elements; in this way the test obtained the appearance of those of some *Difflugia* species. The xenosome-covering of the oral side was always much less dense than that of the fundal one; sometimes it lacked almost completely and in that case the ground structure of the test was clearly perceptible in that place as a fine, rather uniform granulation.

By treating the test with a dilute KOH-solution, a smaller or greater part of the xenosomes came off; tests treatened in this way allowed a close study of the size and form of the aperture and the structure of its margin and surroundings.

This aperture varies only little in size, but very much in form: irregular round, or, owing to the formation of obtuse angles, polygonal; never was the typical triangular form of the aperture observed which. *T. arcula* shows usually and to which the genus owes a part of its name.

The margin of the aperture showed itself in some cases only as a scarcely thickened, dark line; usually, however, as in *T. arcula*, a distinctly developed, thickened, dark brown coloured rim was present. Sometimes it seemed as if this rim bored on its exterior margin a number of irregular placed, very fine grains, which gave them a more or less wart-like appearance.

Remains of the protoplasmatic content were never observed.

Dimensions: diameter of the test (as seen in the direction of the oral-aboral axis) 90—127, heigth 52—60 μ; aperture 10—17, breadth of the rim 1—4 μ.

Nebela certesi.

The sample contained a small number of individuals of this species, limited in its distribution to the southern hemisphere, where it is widely distributed. Lateral pores were always absent, frontal ones always developed, smaller, however, than in *N. martiali*. The margin of the pores was only little or not at all thickened, in the latter case appearing as a fine dark line. Neck pearls normally developed, arranged in two clusters, these separated by an undistinct groove.

Dimensions: long 130—157, broad 70—90 μ; frontal pores wide 5—8 μ.

Nebela?dentistoma.

Only two individuals reminding of this species by the structure of the test and of the aperture, but of smaller dimensions.

Dimensions: long ± 70, broad ± 60 μ.

Nebela lageniformis.

A not numerous, but normal population of this species, rather variable in size and development of the neck, especially with regard to the more or less distinct separation of the fundus from the neck part. Different from *N. certesi* owing to the lack of pores, pearls and neck groove.

Dimensions: long 90—120, broad 43—65 μ.

Nebela penardiana (Fig. 15).

The few tests of this *Nebela* species occurring in the sample showed in general the size, shape and structure, characteristical for this species, but in some cases reminded of the *N. vitraea* test in its structure. The side margins were straight, every indication of a neck wanting. Lateral pores sometimes developed, sometimes indistinct, but probably always present. Breadth and breadth-index very variable.

Dimensions: long 107—133, broad 53—97 μ; some individuals much longer, to ± 170 μ, perhaps belonging to a class of dimensions apart.

Nebela vas.

A very rich, typical population of this southern species. Most individuals showed an unusual structure, the nebeloid ground pattern more or less hidden by a dense covering of small circular or elliptical platelets, with an often thickened margin. These elements of the test reminded somewhat of the „by-plates",

often occurring in the test of some *Quadrula* species, e.g. *Q. scutellata*. Owing to this structure the surface of the test obtained a peculiar, somewhat sparkled appearance; this feature, however, had disappeared in individuals preserved in glycerin-gelatin, probably in consequence of the different refractive index of the medium. On the other hand, these individuals showed very beautifully the narrow-meshed nebeloid ground pattern.

PENARD (1911) says that the population of this species from New Zealand studied by him, represented two classes, different in size, the one normal, 160—165 μ in length, the other much smaller, 95 μ long. Sometimes these two classes occurred together in the same locality; in a single locality, however, only the smaller form was present. We ourselves did not observe this smaller form as yet.

Dimensions: long 143—176, broad 87—117 μ; neck long 43—55, broad at the basis 43—67, at the aperture 37—47 μ.

Euglypha?strigosa.

Beside some small forms of the genus *Euglypha*, which could not be determined with certainty, there was also present a much smaller number of individuals of a larger form, approaching mostly *E. strigosa* on account of the compressed test and the circular aperture, differing, however, from the typical form of this species by the dimensions of the test and by the structure of the plates bordering the aperture. The latter were always smooth, only in a few cases on their outside somewhat rough, owing to the presence of one or more undistinct knobs. Most of the individuals possessed — sometimes paired — spines; they failed, however, partially or completely in otherones.

Trinema enchelys.

Only few individuals of a large form of this species.

Dimensions: long 97—107, broad 50—57 μ; aperture long 20—21, broad 20 μ.

5. *Zygodon Menziesii* (SCHWAEG.) W. ARN.; Napier; collected 1874, investigated 1939.

Arcella ?hemisphaerica PERTY.	1
,, spec.	1
Centropyxis spec.	1
Bullinula indica PEN.	4
,, *minor* nov. spec.	5
Difflugia lucida PEN.	1
Phryganella hemisphaerica PEN. spec.	1
Euglypha spec.	1
Assulina muscorum GREEFF.	2

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Corythion dubium Taran.   1
Trinema complanatum Pen.   1
   „   *enchelys* (Ehrbg.) Leidy.   1

Fig. 15   Fig. 16   Fig. 17

Bullinula indica (Fig. 16).

A rather numerous population of this species, of normal dimensions and test structure, the colour of the test dark brown to almost black. The individual of Fig. 16 represented probably a monstrous form in which the upper lip was drawn out in a sloping-rooflike projection.

Dimensions: long 163—167, broad 147—153 μ; the monstrous individual long 173, broad 160 μ.

Bullinula minor nov. spec. (Fig. 17).

The sample contained a numerous population of a Rhizopod species, as far as we know yet unobserved and undescribed which in our opinion doubtlessly belongs to the genus *Bullinula* Pen., but which deviates from the only species known thus far, *B. indica* Pen., in several respects sufficiently to be described as an autonomous species. The most conspicuous, although perhaps not the most essential, characteristic was the much smaller size; therefore we propose for this form the specific name of *Bullinula minor*. After discovering it in the sample from New Zealand, we found it again in material from Greenbank (N.J., U.S.A.), in an almost identical form, but only in one single specimen.

Habitus, shape, colour and structure of the test showed in general many striking resemblances with that of *B. indica;* all this features, however, often showed slight aberrations, difficult to describe in words or to delineate in drawings.

As seen in the direction of the oral-aboral axis, the test showed a very regular broad elliptical or nearly circular outline,

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the border of which being usually very smooth by the lack of projecting xenosomes. Observed from aside, the form appeared strongly compressed with a heigth of in mean $^1/_3$—$^1/_2$ of the greatest diameter.

The colour varied but little; it was dark yellow, with a sometimes more bright, in other cases more dark brown shade. The thickness of the wall seemed to be but small; therefore, the test never showed the opaque, sometimes nearly black appearance of that of *B. indica*. Especially in the bright tinted individuals the cleft of the aperture shone feebly but distinctly through the fundus wall of the test.

In the structure of the test in general the idiosomatic, pseudochitinous ground substance predominated, especially on the oral sides. On the other hand, the xenosome-covering was but moderately developed; it existed mainly of some scattered quartz grains, and among them sometimes rather numerous sapropelium particles, a structure, quite different from the often so dense and blunt mosaic which adorns the tests of *B. indica* and also from those of *Trigonopyxis arcula* from some localities.

The structure of the oral field is in the main the same as that of *B. indica*. The cleft of the aperture in vertical projection showed itself narrow elliptical with undulating margins, upper and under lip normally developed, with, on account of a more dense accumulation of the pseudo-chitin, a thickened and darker coloured rim, the upper lip often projecting in a triangular tip. By the usually great transparency of the test, it was possible to study the structure and the shape of the aperture also from aside. In this way, the aperture, lying in a distinct inward bending of the test plane, upper and under lip appeared to be placed on very different levels. In many cases the consequence of this was that the plane of the aperture stood more or less perpendicular on the oral plane of the test, and the aperture itself, so observed, appeared much less cleft-like and wider than one would presume by observation of the test in the projection position in which it usually presents itself. Also in *B. indica* a similar phenomenon can sometimes be observed, but seldom so distinct as in the case of *B. minor*.

The pores in the upper lip, a feature so extremely characteristic for *B. indica*, were in *B. minor* in regard to number, size and arrangement, normally developed.

PENARD (1912) mentions variants of *B. indica* also of unusually small dimensions: long 130—170, and 120—125 μ. Also JUNG (1934) observed such small forms, among them one of 90 (126) μ length. As may be seen from the results of our measurings our form was yet considerably smaller, moreover, transitory forms between this form and the also in the sample occuring *B. indica* being entirely absent, we may the more be justified in describing this form as an autonomous species.

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Dimensions: long 77—102, broad 70—83 μ; cleft of the aperture long 23—27, broad — in vertical projection — $\pm$ 7 μ.

III. Literature.

CASH, J., J. HOPKINSON and G. H. WAILES, The British Freshwater Rhizopoda and Heliozoa. London, Ray Society; II, 1909; III, 1915; IV, 1919).

CERTES, A., Protozoaires (Miss. Scient. Cape Horn VI, Zoologie III, 1889).

DEFLANDRE, G., Le Genre Centropyxis (Arch. f. Protistenk. 67, 1929).

DEFLANDRE, G., Etude monographique du Genre Nebela Leidy (Ann. d. Protistolog. 5, 1936).

HEINIS, F., Die Moosfauna Columbiens (Mém. Soc. Neuchâtel 5, 1914).

HOOGENRAAD, H. R. und A. A. DE GROOT, Moosbewohnende Thekamoeben von Java und Sumatra (Treubia 17, 1940).

HOOGENRAAD, H. R., Einige Beobachtungen an Bullinula indica Penard (Arch. f. Protistenk. 79, 1933).

HOOGENRAAD, H. R. en A. A. DE GROOT, Thekamoebe Sphagnumrhizopoden van Buitenzorg (Java) (13de Biol. Jaarb., Dodonaea, 1946).

JUNG, W., Beobachtungen an der Moor-Thekamoebe Bullinula indica Penard (Abh. Westf. Prov. Mus. 5, 1934).

OYE, P. VAN, Au sujet de la distribution géographique des Rhizopodes (11de Biol. Jaarb., Dodonaea, 1944).

PENARD, E., Rhizopodes d'eau douce (Rep. Brit. Antarct. Exp. 1907—1909, Vol. I, Biology, Part VI, 1911).

PENARD, E., Notes sur quelques Sarcodinés. IIIiéme Part (Rev. Suisse Zool. 20, 1912).

WAILES, G. H., Freshwater Rhizopoda and Heliozoa from the States of New York etc. (Journ. Linn. Soc. Zool. 32, 1912).

WAILES, G. H., Freshwater Rhizopoda from North and South America (Journ. Linn. Soc. Zool. 32, 1912).

IV. Explanation of the Figures.

Fig. 1. **Centropyxis ?ecornis,** from aside. × 550.
„ 2. **Centropyxis ?ecornis,** seen from below, aslant. × 550.
„ 3. **Difflugia lucida,** from aside. × 500.
„ 4. **Difflugia** spec. × 500.
„ 5. **Nebela cockayni,** a from aside, b in front view. × 550.
„ 6. **Nebela cockayni,** two individuals in front view. × 550.
„ 7. **Nebela cockayni,** two individuals in front view, with indication of the nebeloid structure. × 550.
„ 8. **Nebela cockayni,** variant, with indistinct cross contraction. × 550.
„ 9. **Nebela martiali,** a front view, b from aside. × 375.
„ 10. **Nebela martiali,** a, b front view, c from aside. × 375.
„ 11. **Nebela martiali,** from aside. × 375.
„ 12. **Nebela vas,** front view, with indication of the structure. × 520.
„ 13. **Trigonopyxis microstoma,** a from aside, b from above, with the aperture perceptible through the fundus wall. × 520.
„ 14. **Trigonopyxis microstoma,** from the oral side, with details of the aperture. × 400.
„ 15. **Nebela penardiana,** front view, with indication of the structure, × 650.
„ 16. **Bullinula indica,** monstrous individual, in outline. × 425.
„ 17. **Bullinula minor,** seen from below, aslant; b circular individual from below, in outline, with aperture and pores. × 500.

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Die Photosynthese des Phytoplanktons vom Gesichtspunkte der Quantenlehre

von

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Von den Ergebnissen der Sauerstoffschichtungs-Unter-
suchungen der letzten Jahrzehnten geht es hervor, dass der
maximale O_2 Gehalt des Meer-bzw des Seewassers, durchaus
nicht unmittelbar unter dem Wasserspiegel, sondern recht oft
in einer *bedeutenden Tiefe* (10—15 m) nachweisbar ist. Vor
25—30 Jahren konnte diese Erscheinung noch nicht befriedi-
gend erklärt werden, da die ökologische Verhältnisse der Ge-
wässer damals noch nicht genügend erforscht waren.

Man kann sich zwei Quellen des im Wasser gelösten Sauer-
stoffs vorstellen. Die erste dieser ist der O_2 Vorrat der Atmos-
phäre, die zweite die photosynthetische O_2 Entbindung der Pro-
duzenten. Nachdem die Schicht in der das O_2 Maximum beobach-
tet wird, meistens durch eine dicke Wasserschicht von der At-
mosphäre abgesondert ist, wo ausserdem die Lichtstärke der
Sonnenstrahlung, in Folge der Absorbtionsfähigkeit des Was-
sers, auch bedeutend verringert ist, konnte vor einigen Jahr-
zehnten diese Erscheinung nicht erklärt werden, weil dann
noch die Ansicht vorherrschte, dass die photosynthetische Tä-
tigkeit der Produzenten umso reger vor sich geht, je grösser
die Intensität der Lichtstrahlen ist.

Die Versuche welche Verfasser im Jahre 1922 mit dem Phy-
toplankton des *Velencesees* ausgeführt hat, (5) haben es aber
gezeigt, dass die Photosynthese sich nur bis zu einer Grenze
mit der Lichtstärke vergrössert, bei einem weiteren Zuwachs
der Strahlungsintensität vermindert sie sich allmählich wieder
und von einer gewissen Lichtstärke an wird sie sogar gänzlich
aufgehoben. Es gibt also eine *optimale* Lichtstärke, bei wel-
cher die photosynthetische Produktion maximal wird und eine
inaktive, oder *schädliche,* wo die Produktion, ebenso wie beim
völligen Lichtmangel, zu einem *Stillstand* kommt.

Gleiche Verhältnisse wurden einige Jahre später (1928) von
Marshall und Orr (4) auch für das *marine* Phytoplankton
nachgewiesen.

Die Berechnungen haben es gezeigt, dass die photosynthe-
tische Produktion des Phytoplanktons sich nach Gesetzmässig-
keit der Sinusfunktion mit der Lichtstärke verändert, was
durch die Gleichung :

$$P = a \sin I \dots\dots\dots\dots\dots\dots\dots \qquad 1$$

dargestellt ist, in der $I = bJ$ eine der Lichtstärke J proportionale, dimensionslose Grösse, b ein Proportionalitätsfaktor und a die Amplitude der Produktion bedeuten.

Nachdem wir für die Intensität des Sonnenlichtes auf der Erdoberfläche die Gleichung:

$$J = 1{,}087 \; J_o'' \; \omega^2 \sin \mu \dots\dots\dots\dots \qquad 2$$

herbeigeleitet haben, versuchten wir im Jahre 1934, den relativen Wert der optimalen Lichtstärke experimentell zu bestimmen. (7) In Gleichung 2. bedeutet J_o'' die maximale Lichtstärke der direkten Sonnenstrahlung auf der Erdoberfläche. Diese kommt jährlich nur eimal auf einem einzigen Orte des südlichen Halbkugels vor, als dort die Sonne bei völlig klarem Himmel zur Zeit des Perihels im Zenith steht. Sonst wo immer auf der Erde, in jedem anderen Zeitpunkt des Jahres, kann nur eine kleinere Lichtstärke zustande kommen. Die Faktoren ω^2 und $\sin \mu$ in Gleichung 2. ermöglichen die Berechnung der Lichtstärke der direkten Sonnenstrahlen für einen jeden Ort und eine beliebege Zeit, falls man den Wert von J_o' kennt. ω^2 ist eine Zahl, die sich auf die Aenderung der Lichtstärke mit der Sonnenentfernung bezieht, μ ist die Sonnenhöhe.

Es ist bekannt, dass auf die Erdoberfläche nicht nur direkte, sondern auch indirekte Strahlen eintreffen, welche durch Reflexion auf den Molekeln der atmosphärischen Gase und auf der Oberfläche der schwebenden festen und flüssigen Körperchen (Staub, Wassertropfen u.s.w.) entstehen. Der Faktor 1.087, der auf Grund der Untersuchungen von DORNO (1), JUDAY (10), SUCHLANDT und SCHMASSMANN (12) berechnet wurde, ist eine Korrektionszahl, die wegen der Einwirkung dieser diffusen Strahlung in Rechnung gezogen werden soll.

Ueber weitere Aufschlüsse verweisen wir auf die Originalabhandlung des Verfassers. (7)

Da $I = bJ$ ist folgt, dass bei optimaler Beleuchtung

$$I = b . 1{,}087 . J_\bullet'' \; \omega^2 \sin \mu = \frac{\pi}{2} \dots\dots \qquad 3$$

sein muss. In diesem Falle wird

$$J_o'' = \frac{\dfrac{\pi}{2}}{b . 1{,}087 . \omega^2 \sin \mu}$$

Da die maximale irdische Lichtstärke eine konstante Grösse ist, muss falls $I = \dfrac{\pi}{2}$ ist auch der Ausdruck $\dfrac{1}{\omega^2 \sin \mu} = \varkappa$ eine Konstante sein, weil sämtliche übrigen Glieder Konstanten sind. Den Zahlenwert von $\varkappa$ hat Verfasser experimentell bestimmt und *diesen für 6,481 gefunden.*

Es kann also geschrieben werden, dass

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$$J_0^{''} = \frac{\varkappa}{1{,}087\,b} \cdot \frac{\pi}{2}$$

Setzt man das in Gleichung 2. ein, dann erhällt man die Gleichung

$$I = bJ = \varkappa\,\omega^2 \sin\,\mu\,\frac{\pi}{2} \dots\dots\dots\dots\dots\dots\dots 4.$$

mit der man die relative Lichtstärke (die auch die diffuse Strahlung umfasst), für einen beliebeigen Ort und Zeitpunkt berechnen kann, indem ω^2 gegeben ist, und $\sin\,\mu$ sich mit der gutbekannten Gleichung

$$\sin\,\mu = \sin.\,\varphi\,\sin\,\delta + \cos\,\varphi\,\cos\,\delta\,\cos t \dots\dots\dots 4a.$$

leicht berechnen lässt. In dieser Gleichung bedeuten φ die geographische Breite des Ortes, δ die Deklination der Sonne und t den Stundenwinkel.

Aus Gleichung 4. folgt, dass die grösste irdische Lichtintensität die 6,481-fache der optimalen ist. Unter der geographischen Breite von Budapest (47° 30') ist diese zur Zeit des Sommersolstitiums die 5,41-fache und beim Wintersolstitium die 2,11-fache der optimalen. Ja sogar auf dem Nordpol überschreitet die sommerliche Lichtstärke die optimale 2,37-mal. Es kann demnach kein Ort auf der Erde gezeigt werden, wo eine dauerhafte überoptimale bzw inaktive Beleuchtung nicht zustande kommen dürfte.

Weiters ist aus Gleichung 4. zu ersehen, dass die Intensität des Sonnenlichtes auf der Erdoberfläche sich periodisch verändert, sie ist also eine Funktion der Zeit. Die veränderlichen Grössen der Gleichung 4., also das Produkt $\omega^2 \sin\,\mu$ kann sich aber nur binnen den Grenzen 0 und 1 mit der Zeit verändern. Der maximale Wert von ω^2 ist 1, zur Zeit des Perihels und der minimale 0,92123, bei Aphel. Der Zahlenwert von $\sin\,\mu$ kann sich natürlich nur zwischen den Grenzen 0 und 1 verändern. Demzufolge kann das Produkt $\omega^2 \sin\,\mu$ ebenfalls nur Werte von 0 bis 1 aufnehmen, es ist also ein wahrer Bruch. Jenachdem

$$\omega^2 \sin\,\mu = 0,\ \frac{1}{\varkappa},\ \frac{2}{\varkappa},\ \frac{3}{\varkappa},\ \frac{4}{\varkappa},\ \dots\dots\dots\ \frac{n}{\varkappa}$$

ist, nimmt I der Reihe nach die Werte:

$$I = 0,\ \frac{\pi}{2},\ \frac{2\,\pi}{2},\ \frac{3\,\pi}{2},\ \frac{4\,\pi}{2},\ \dots\dots\dots\ \frac{n\,\pi}{2}$$

an. Obwohl der Wert des Produkts sich nicht unbeschränkt (nur bis 1) vergrössern kann, befriedigt Gleichung 4. doch sämtliche biologische Ansprüche, weil die Photosynthese schon binnen den Grenzen n = 0 und n = 2 völlig vor sich geht. Ueber die obere dieser Grenzen herrscht ja schon die inaktive Lichtstärke, bei welcher die Assimilation ebenso zu einem Stillstand kommt, wie beim vollständigen Lichtmangel. Die Gleichung behält aber ihren physikalischen Sinn über diese Grenze hinaus, wovon

sich erkennen lässt, dass einer ganzen Periode, bis nämlich I von 0 bis $\frac{4\pi}{2}$ zunimmt, die Zeitdauer $\vartheta = \tau$ entspricht, während der sich n von 0 bis 4 vergrössert. So oft n um eine Einheit grösser wird, verfliesst die Zeit einer Viertelperiode $\left(\frac{\tau}{4}\right)$. n ist also die Zahl der Viertelperioden im Laufe der Zeit, demnach ist sie durch den Bruch $n = \dfrac{\vartheta}{\dfrac{\tau}{4}}$ gegeben.

Setzt man in Gleichung 4 statt $\omega^2 \sin \mu$ den Bruch $\dfrac{n}{\varkappa}$ ein und berücksichtigt die soeben Gesagten, dann wird:

$$I = n \frac{\pi}{2} = \frac{2\pi\vartheta}{\tau}$$

Indem $\dfrac{1}{\tau} = \nu$, die Frequenz der periodeischen Aenderung der Lichtenergie ist, folgt dass

$$I = 2\pi\nu\vartheta \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad 5.$$

oder:

$$I = a\,\vartheta \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad 5a.$$

weil $2\pi\nu = a$, eine konstante Grösse ist.

Aus den vorhergehenden Betrachtungen lassen sich ökologisch wichtige Schlüsse ziehen. Erstens kann nun die Tiefenlage des Sauerstoffmaximums leicht erklärt werden. Das kommt in der Wasserschicht zustande, wo die Lichtstärke der an dem Wasserspiegel anprallenden überoptimalen (inaktiven) Strahlung durch die Lichtabsorbtion des Wassers bis auf die optimale herabgeschwächt ist. Es ist offenbar, dass die weit unter der Intensität des direkten Sonnenlichtes bleibende optimale Lichtstärke als eine Anpassung an den kleinsten irdischen Lichtintensitäten anzusehen ist. Diese Einrichtung befähigt die Phytoplanktonalgen, als Hauptproduzenten der Gewässer, woimmer auf der Erde, auch in den Polargebieten unter optimalen Lichtverhältnissen organische Verbindungen aufzubaun. Wäre das nicht so, wäre z. B. die Lichtstärke der tropischen Gegenden gleich der optimalen, so könnten die Algen nur in den Tropen, auch dort nur unmittelbar unter dem Wasserspiegel optimal produzieren. Wir sahen aber, dass die sommerliche Lichtstärke sogar in den Polarregionen bedeutend grösser als die optimale ist. Darum existiert auf der Erde kein einziger Ort, wo die Wasseroberfläche nicht durch inaktives Licht gestreifft sein dürfte. Dieser Umstand ist sehr wichtig, indem die Intensität der Strahlung teils durch Reflexion auf dem Wasserspiegel, teils durch Absorbtion und Extinktion im Wasser selbst, stark herabgesetzt wird. Gegen die schädliche Einwirkung des überoptima-

len bzw des inaktiven Lichtes, kann sich das Phytoplankton dadurch mit Erfolg schützen, dass es sich in die tiefere Wasserschichten zurückzieht, wo die Lichtstärke schon bis auf die optimale herabgestufft ist.

Die Erfahrung unterstützt diese Annahme in grösstem Masse. Es ist ja eine alte Beobachtung, dass das marine Phytoplankton in einem umso tieferen Wasserschicht in grösster Menge gefunden wird, je mehr man sich in der Richtung von den Polen gegen den Aequator nähert. SCHIMPER hat die Beobachtung gemacht, dass die Chromatophoren der Algen, welche aus der oberflächlichen Schichten des tropischen Meeres herstammten, zusammengeschrumpft und blass waren und in Folge dessen, die Algen selbst verkümmert aussahen. Gesunde Phytoplanktonalgen können in den Tropen nur von tiefen Wasserschichten eingeholt werden.

In dem mässigen Wert des Optimums findet man die Erklärung auch dieser Beobachtung, wonach der Reichtum der Biocönosenbevölkerung im Allgemeinen gegen den Polen zunimmt, welcher Umstand gewiss in kausalen Zusammenhang mit dem Reichtum der Festlandbiocönosen der Polgebieten stehen dürfte.

Da die Aenderung der Lichtstärke auf der Erdoberfläche periodisch vor sich geht, welche Periodizität von kosmischen Faktoren u.zw. von den Bewegungen der Erde um die Sonne und um ihre eigene Achse bedingt ist, wobei der Kugelgestalt der Erde und dem Neugugnswinkel der Ekliptikebene auch eine Rolle zukommt, kann das ozeanische bzw das limnische Holocön für einen Resonator aufgefasst werden. Das biologische Geschehen in diesen Lebensräumen geht im Sinne der periodischen Schwankungen der Lichtenergie vor sich, da die Gesamtbiocönose durch die photosynthetisch aufgebauten organischen Verbindungen erhalten wird. In Folge der Anpassung der Phytoplanktonalgen an die kosmischen Milieufaktoren weist auch das biologische Geschehen eine dem Rhythmus des Sonnesystems gleichwerdende Periodizität auf. Das ist eigentlich die Offenbarung des KIRCHHOFFSCHEN Gesetzes auf dem Gebiete der Biologie. Von diesem Umstand wird es ermöglicht, dass wir hier auf Grund der Analogien zur Erklärung einiger Erscheinungen die Sätze der modernen Physik in Anspruch nehmen.

Deswegen wollen wir das aus Wasser und Phytoplankton bestehende System für ein makrohaterogenes chemisches System betrachten, wo das Wasser als eine verdünnte Lösung von CO_2 die flüssige und die Algenzellen die feste Phase darstellen. Die Reaktionsgeschwindigkeit solcher Systeme wird nach NERNST und BRUNNER (9) durch die Diffusionsgeschwindigkeit des wirkenden Stoffes, also in diesem Falle des Kohlendioxyds, beherrscht.

Nach FICK (2) ist die Diffusionsgeschwindigkeit durch die Gleichung

$$\delta = \frac{ds}{dt} = -\,D\,\varphi\,\frac{dc}{dx}$$

darstellbar, wo ds die Menge des während des Zeitelements dt durch die Fläche φ in der Richtung der x Achse diffundierenden gelösten Stoffes bedeutet, falls dem Streckenelement dx die Konzentrationsverminderung dc entspricht und D die Diffusionskonstante ist. Nach Einsetzen des stationären Zustandes kann δ als eine konstante Grösse anbetrachtet werden. Stellt man sich einfachkeits halber die Algen als gleichgrosse, kugelförmig gestalteten Individuen vor, dann wird:

$$\int_{0}^{\varrho} \delta\,dx = -\int_{c_0}^{c_\varrho} D\varphi\,dc$$

wo ϱ den mittleren Halbdurchmesser der Algen, c_0 und c_ϱ die Konzentration des Kohlendioxydes im Wasser (äussere Konzentration) bezw im Innern der Algenzellen (innere Konzentration) bedeuten. Nach Durchführung der Integration erhält man für die Diffusionsgeschwindigkeit:

$$\delta = \frac{D\,\varphi}{\varrho}\left[c_0 - c_\varrho \right]$$

Der Assimilationsprozess geht im Innern der Algenzellen als in einem homogenen System vor sich. Es ist nun die Reaktionsgeschwindigkeit des Prozesses auf die Volumeneinheit bezogen

$$\frac{dc_\varrho}{dt} = -\,kc_\varrho,$$

wenn k die Geschwindigkeitskonstante des Assimilationsvorganges ist. Diese ist eine Funktion der Lichtstärke, indem sie sich nach den Folgenden zwischen den Grenzen $c_\varrho = 0$ und $c_\varrho = c_0$ proportional der durch die Algen absorbierten Lichtenergie vergrössert. Auf das Volumen einer Alge bezogen wird demnach die Reaktionsgeschwindigkeit der Assimilation durch die Gleichung:

$$\psi\,\frac{dc_\varrho}{dt} = -\,k\,\psi\,c_\varrho$$

gegeben sein, wenn ψ das mittlere Volumen der Algen ist.

Nach Nernst und Brunner (9) wird die Assimilation durch die Diffusionsgeschwindigkeit des CO_2—s beherrscht, d. h. es werden nur so viel CO_2 Molekeln im Innern der Algenzellen assimiliert, als dorthin diffundieren können.

Hier handelt es zich um das Gleichgewicht zweier entgegengerichteten Kräfte, und zwar der mit den inneren und äusseren Konzentrationen des CO_2 Gehaltes proportionalen osmotischen Drucken, wir haben also mit einem System *quasi-elastischer* Kräfte zu tun. In solchen Systemen wird durch die impulsieve Einwirkung einer äusseren Kraft eine Schwingung erregt,

welche man als *Eigenschwingung des Systems* bezeichnet. Von dem Prinzip der Erhaltung der Energie wird nun erwünscht, dass die Gesamte Energie des Systems in jeder Phase der Schwingung konstant erhalten bleibt, wofür das Kriterium die Beständigkeit der Summe der kinetischen und potentiellen Energien des Systems liefert.

Die in Form petentieller Energie in den gebildeten Kohlenstoffverbindungen gespeicherte Lichtenergie, ist in Folge der Beständiget des Assimilationsquotienten proportional der Menge des assimilierten Kohlendioxyds. Auf dieser Grundlage kann die Gesamtenergie des photosynthetischen Prozesses berechnet werden, wenn man die NERNST-BRUNNERSCHE Regel auch in Betracht nimmt.

Die innere Konzentration kann nämlich niemals grösser, höchtens nur gleich der äusseren werden, indem ja die Kohlensäure vom Wasser in das Innere der Algenzellen diffundiert. Darum schwankt ihr Wert binnen den Grenzen $c_\varrho = 0$ und $c_\varrho = c_0$. Es können demnach während der Zeiteinheit *maximal* nur $k \psi c_0$ Grammäquivalenten des Kohlendioxyds assimiliert werden, welche CO_2 Menge nach den oben Gesagten proportional der gespeicherten Lichtenergie ist, d. h. es besteht die Gleichung $k \psi c_0 = \gamma E$, wo E die gespeicherte Energie und γ einen Proportionalitätsfaktor bedeuten.

Der *maximale* Wert der Diffusionsgeschwindigkeit, (also die Menge des während der Zeiteinheit in das Zelleninnere dringenden Kohlendioxyds) ist durch die Formel $\delta = \dfrac{D \varphi}{\varrho} c_0$ gegeben, da die Diffusionsgeschwindigkeit proportional der Differenz $(c_0 - c_\varrho)$ ist, die ihren maximalen Wert erreicht falls $c_\varrho = 0$ wird. Nun soll nach der NERNST-BRUNNERSCHEN Regel die Bedingung erfüllt sein, wonach die maximale Diffusionsgeschwindigkeit mindestens gleich der maximalen Reaktionsgeschwindigkeit ist, da sonst die erforderliche CO_2 Mengen für die Reaktionsgeschwindigkeiten die einer jeder inneren Konzentration zwischen den Extremen $c_\varrho = 0$ und $c_\varrho = c_0$ entsprechen, nicht zur Verfügung stehen könnten. Diese Bedingung wird durch die Gleichung

$$\left[\frac{D \varphi}{\varrho} c_0 \right] = \left[- k \psi c_0 \right] = \gamma E$$

ausgedrückt, woraus aber keineswegs gefolgert werden darf, dass die maximalen Diffusions- und Reaktionsgeschwindigkeiten zur gleicher Zeit erfolgen. Im Gegenteil sind diese Grenzfälle, zwischen denen beide Vorgänge sich in entgegengesetzter Richtung derart ändern, dass die Summe der während der Zeiteinheit in die Zellen eindringbaren und dort gleichzeitig assimilierbaren Kohlensäure stets eine konstante Grösse bleibt. So

wird es ermöglicht, dass die erforderliche CO_2 Menge dem Assimilationsvorgange entweder als Vorrat, dessen Grösse durch die innere Konzentration gegeben ist, oder als hinzuströmende Kohlensäure, deren Diffusionsgeschwindigkeit in demselben Masse zunimmt, in welchem die innere Konzentration (also der Vorrat) sich verringert, immer vorhanden ist. Daraus folgt, *dass die maximale Energie, die wir als Gesamtenergie des photosynthetischen Vorganges bezeichnen,* im ersten Grenzfalle, wann also $c_\varrho = 0$ ist, sich allein aus der Diffusionsgeschwindigkeit, im zweiten als $c_\varrho = c_0$ wird, aus der Reaktionsgeschwindigkeit berechnen lässt, weil im ersten Falle $k \psi c_\varrho = 0$, im zweiten $\dfrac{D \varphi}{\varrho} (c_0 - c_\varrho) = 0$ ist. In den Zwischenfällen kann hingegen die Gesamtenergie als eine der Summe der gleichzeitigen Diffusions- und Reaktionsgeschwindigkeiten proportionale Grösse dargestellt werden. Nachdem wir die Phytoplanktonalgen für kugelförmig gestalteten Körperchen betrachten, darf man statt φ den Ausdruck $\dfrac{3 \psi}{\varrho}$ in die letzte Gleichung setzen. So wird: $\dfrac{3 D \psi}{\gamma \varrho^2} c_0 = \dfrac{k \psi}{\gamma} c_0$, wovon $\varrho = \sqrt{\dfrac{3 D}{k'}}$ sein muss.

Da die Diffusionskonstante (D) ihrer Grössenordnung nach weitaus kleiner als die Geschwindigkeitskonstante (k) des Assimilationsvorganges ist, geht aus dieser Gleichung hervor, dass die bei maximaler Produktion verbrauchte CO_2 nur dann durch Diffusion ersetzt wird, wenn die Radien der Kugelförmigen Algen selbst, sehr klein sind. Die Bedeutung dieses Umstandes liegt an der Hand, da in Folge der durch die kleine Körperdimension verursachte relative Oberflächenvergrösserung nunmehr die Kohlensäure entsprechend der NERNST-BRUNNERSCHEN Regel durch Diffusion wannimmer in ausreichender Menge dem Assimilationsvorgange dargeboten werden kann. Die soeben Gesagten stehen mit der Erfahrung in bester Uebereinstimmung, indem wir wissen, dass die Phytoplanktonalgen nur mit Mikroskop wahrnehmbare, meistens einzellige, sehr kleine Lebewesen sind.

Die maximale Energie des photosynthetischen Vorganges kann demnach entsprechend der zwei Grenzfälle der inneren Konzentration ($c_\varrho = 0$ und $c_\varrho = c_0$) durch die Gleichungen:

$$\frac{D \varphi}{\varrho \gamma} c_0 = E \quad \text{bzw.} \quad \frac{k \psi c_0}{\gamma} = E \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad 7.$$

berechnet werden. Da wir einfachkeitshalber die Phytoplanktonalgen für kugelförmig gestalteten Körperchen betrachten, darf die erste dieser Gleichungen auch in der Form $\dfrac{k \psi}{\gamma} c_0 = E$

geschrieben werden. Gehen wir nun von den zweiten dieser Grenzfäflen aus, wenn also $c_\varrho = c_0$ ist. Das erfolgt in der Natur nach einer andauernden Pause des Assimalationsvorganges, z.B. in den frühmorgens Stunden, vor dem Sonnenaufgange. Da der Diffusionsvorgang im Gegensatz zu der Assimilation, auch im Dunkelheit vor sich geht, gleichen sich während der Nacht die innere und äussere Konzentrationen aus. Im Augenblicke als die ersten Lichtstrahlen die Algen treffen, die Assimilation aber noch nicht im Gange gesetzt ist, ergibt sich die mögliche Diffusionsgeschwindigkeit, die wir *Diffusions-*

fähigkeit bezeichnen wollen zu O, da $\delta = \dfrac{D\,\varphi}{\varrho}\,(c_0 - c_0) = O$

ist. Die Reaktionsgeschwindigkeit $k\ \varphi\ c_0$ des Assimilationsvorganges, welche in diesem Moment noch ebenfalls nicht besteht, nur als eine *Reaktionsfähigkeit* aufzufassen ist, hat aber ihren maximalen Wert, weil c_0 der grösste Wert von c_ϱ ist. Als die Assimilation in Folge der inpulsiven Einwirkung des Lichtes beginnt, vermindert sich die innere Konzentration und damit auch die anfangs maximale Reaktionsfähigkent, in gleichem Masse vergrössert sich aber die Differenz $(c_0 - c_\varrho)$ und proportional dazu die Diffusionsfähigkeit. Es ist leicht einzusehen, dass die entgegengerichtete Veränderung beider Vorgänge schliesslich zum stationären Zustand führt. Dieser ist eigentlich *der Eigenschwingung eines Systems quasi-elastischer Kräfte analog*, welcher sich in einem um die Gleichgewichtslage schwankenden, kinetischen Gleichgewichtszustand äussert. Je grösser der Impuls, also die Intensität des Lichtes war, umso mehr wird die Reaktionsgeschwindigkeit der Assimilation befördert, weil mehr Lichtenergie der Photosynthese zur Verfügung gestellt wird. Das hat eine gesteigerte Verminderung der inneren Konzentration zur Folge, so dass der stationäre Zustand jetzt bei einem entsprechend kleineren Wert von c_ϱ zu Stande kommt. Doch kann das nur soweit gehen, bis die innere Konzentration ausreicht. Ist nämlich die Lichtenergie viel zu gross, dann verringert sich c_ϱ schliesslich zu O. In diesem Moment nimmt zwar die Diffusionsfähigkeit ihren maximalen Wert an, die Reaktionsfähigkeit wird hingegen zu O, d. h. *die Photosynthese kommt zu einem Stillstand, wir haben mit inaktiver Lichtstärke zu tun.* In dieser Weise wird die andere Grenze erreicht über welche hinaus die Assimilation schon nicht mehr vor sich gehen kann. In welchem Masse die Reaktionsfähigkeit sich bis zu dieser Grenze vermindert, im gleichen Verhältniss nimmt die Diffusionsfähigkeit zu. Die Diffusionsfähigkeit ist für einen beliebeigen Zeitpunkt durch die Gleichung

$$\delta = k\psi \mid c_0 - c_\varrho \mid = k\psi\ c_0 - k\psi\ c_\varrho$$

geben, falls man die Algen für kugelförmig gestaltete Körper-

chen betrachtet. Dividiert man diese Gleichung durch γ , so erhält man

$$\frac{k\psi}{\gamma}(c_0 - c_\varrho) = \frac{k\psi}{\gamma}c_0 - \frac{k\psi}{\gamma}c_\varrho \text{ , woraus sich die Gleichung}$$

$$\frac{k\psi}{\gamma}c_0 = \frac{k\psi}{\gamma}(c_0 - c_\varrho) + \frac{k\psi}{\gamma}c_\varrho \text{ ergibt.}$$

Da $\frac{k\psi}{\gamma}c_0 = E$, die maximale Energie des Assimilationsvorganges ist, gelangt man zu der Gleichung:

$$E = \frac{k\psi}{\gamma}(c_0 - c_\varrho) + \frac{k\psi}{\gamma}c_\varrho \quad \ldots \ldots \ldots \ldots \ldots 8.$$

welche aussagt, dass *die Summe der Energimengen, welche proportional der CO_2 Menge die einerseitz der Diffusionsfähigkeit, anderseits der Reaktionsfähigkeit entspricht, während des Assimilationsvorganges eine konstante Grösse bleibt.*

Vergleicht man diese Verhältnisse mit diesen der Pendelbewegung, so lässt sich die Analogie beider Vorgänge leicht verfolgen. Es handelt sich hier um eine Viertelperiode $\left(\frac{\tau}{4}\right)$ 'der Pendelbewegung. Der Ausgangpunkt des obengeschilderten Vorganges entspricht dem maximalen Ausschlag (Amplitude) der Pendelbewegung, wann also die kinetische Energie des Pendels O, die potentielle hingegen maximal ist und die Geschwindigkeit des Pendels für ein Moment verschwindet. Von hier an nimmt die kinetische Energie des pendels im gleichem Masse, in welchem sich die potentielle vermindert, zu, so dass die Summe beider Energiearten beständig bleibt. Die kinetische Energie wird in senkrechter Lage des Pendels, welche dem Anfangspunkte der inaktiven Lichtstärke entspricht, maximal, wo aber die potentielle Energie zu Null wird.

Aus diesen Betrachtungen geht also hervor, dass die Summe der Diffusions- und Reaktionsfähigkeiten auch eine *konstante Grösse* ist, welche der Summe der kinetischen und potentiellen Energien bzw *der Gesamtenergie des photosynthetischen Vorganges* proportional sein soll. Nach Gleichung 8. lässt sich das mathematisch folgendermassen darstellen:

$$\gamma E = k\psi(c_0 - c_\varrho) + k\psi c_\varrho = A = \gamma(e_k + e_p)$$

wo A eine Konstante, e_k bzw e_p die kinetische bzw die potentielle Energien sind. Aus dieser Gleichung folgt, dass:

$$E = \frac{k\psi}{\gamma}(c_0 - c_\varrho) + \frac{k\psi}{\gamma}c_\varrho = \frac{A}{\gamma} = e_k + e_p \quad \ldots \quad 9.$$

wo analogerweise $\frac{k\psi}{\gamma}(c_0 - c_\varrho) = e_k$ die kinetische und $\frac{k\psi}{\gamma}c_\varrho = e_p$ die potentielle Energie darstellt.

Multipliziert und dividiert man die Rechte Seite der Glei-

chung 9. durch $2a^2c_0$, wo a^2 eine beliebige Zahl sein kann, dann erhält man:

$$E = \frac{2k\psi}{2\gamma a^2} a^2 c_0 \left(1 - \frac{c_\varrho}{c_0} \right) + \frac{2k\psi}{2\gamma a^2} a^2 c_0 \frac{c_\varrho}{c_0}$$

Schreibt man statt dem aus Konstanten bestehenden Quotienten $\frac{2k}{\gamma a^2}$ die gemeinschaftliche Konstante ξ, so wird

$$E = \frac{\psi \xi}{2} a^2 c_0 \left(1 - \frac{c_\varrho}{c_0} \right) + \frac{\psi \xi}{2} a^2 c_0 \frac{c_\varrho}{c_0}$$

Nachdem c_ϱ naturgemäss niemals grösser, höchstens nur gleich c_0 werden kann, ändert sich der Wert des Quotienten $\sqrt{\frac{c_\varrho}{c_0}}$ zwischen den Grenzen von 0 und 1, darum kann ein jeder Wert desselben durch den Sinuswert einer *beliebigen* x Grösse ersetzt werden, man erhält deswegen die Gleichung:

$$E = \frac{\psi \xi}{2} a^2 c_0 \cos^2 x + \frac{\psi \xi}{2} a^2 c_0 \sin^2 x,$$

da $\cos^2 x = 1 - \sin^2 x$ ist.

Die Assimilation vollzieht sich in der Zeit, darum ist x auch eine Funktion der Zeit. Im einfachsten Falle dürfte $x = a\vartheta$, also proportional der Zeit sein. Es lässt sich nun zeigen, dass das auch jetzt der Fall ist, da die letzte Gleichung nur bestehen kann, wenn sämtliche Glieder auf beiden Seiten von der Dimension der Energie sind, eine Bedingung, die nur erfüllt ist, wenn $x = a\vartheta$ ist. Der zweite Glied auf der rechten Seite stellt die potentielle Energie der Photosynthese dar. Nachdem $\sqrt{c_0} \sin x = q$ immer durch eine Strecke [1]) dargestellt werden kann, hat sie die Dimension der Länge, $\psi \xi$ ist eine der Gewichtsmenge des während der Zeiteinheit assimilierten Kohlendioxyds proportionale Grösse, darum ist ihre Dimension diese der Masse Falls $x = a\vartheta$ wird, die erste Ableitung nach der Zeit von

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[1]) Die Sinusfunktion ist ja eine Verhältniszahl, welche durch den Quotienten zweier Grössen von gleicher Dimension immer dargestellt werden kann. Der Wert des Quotienten wird dabei von der Dimension der Grössen nicht beeinflusst, da dieser nur von dem Verhältnis der numerischen Werten der Grössen abhängt. Im unseren Falle haben wir die Sinusfunktion als eine Verhältniszahl der Quadratwurzeln zweier Konzentrationen ermittelt. Diese können aber durch Strecken mit den genannten Quadratwurzeln gleichen numerischen Werte besitzenden Längen ersetzt werden. Dem entsprechend soll also $\sqrt{c_\varrho} = b_\varrho$ und $\sqrt{c_0} = l_0$ sein, wo l_ϱ und l_0 die entsprechenden Streckenlängen bedeuten. Aus den Gesagten folgt nun, dass:

$$q = \sqrt{c_0} \sin x = \sqrt{c_0} \frac{\sqrt{c_\varrho}}{\sqrt{c_0}} = l_0 \frac{l_\varrho}{l_0} = l_\varrho$$

d.h. die Grösse $q = \sqrt{c_0} \sin x$ kann immer durch die Strecke l_ϱ ersetzt werden.

$q = \sqrt{c_0}\sin x$, also $\dot{q} = a \ \sqrt{c_0}\cos x$ erhält die Demension der Geschwindigkeit und die zweite, $\ddot{q} = - a^2 \sqrt{c_0}\sin x$, diese der

$$\sqrt{c_0}\sin x$$

Beschleunigung $\dfrac{\psi\,\xi}{2}\,a^2\,c_0\sin^2 x = \pm\varphi\xi\Big|_0^{} a^2\ \sqrt{c_0}\sin x.\ d\ \sqrt{c_0}\sin x$

ist demnach die Änderung des Potentials entlang der Strecke $\sqrt{c_0}\sin x$, hat also die Dimension der *potentiellen Energie*, da $-\ \psi\ \xi\ a^2\ \sqrt{c_0}\ \sin x$ die Kraft bedeutet. Nachdem $\psi\,\xi\,\sqrt{c_0}\cos x = p$ nach den Gesagten als Produkt von Masse und Geschwindigkeit die Dimension der *Beweglichkeit* besitzt, also einen *Impuls* darstellt, hat das erste Glied auf der rechten Seite der Gleichung $\dfrac{\psi\,\xi}{2}\ a^2\,c_0\,\cos^2 x$ die Dimension der *lebendigen Kraft*, oder der *kinetischen Energie*. Sämtliche Glieder die auf beiden Seiten der Gleichung stehen haben also die Dimension der Energie, aber nur dann, wenn $x = a\,\vartheta$, proportional der Zeit ist. Unsere Gleichung kann demnach nur bestehen, wenn man statt x den Argument $a\,\vartheta$ einsetzt, so dass die Gleichung jetzt die Form:

$$E = \frac{\psi\,\xi}{2}\,a^2 c_0\,\cos^2 a\,\vartheta + \frac{\psi\,\xi}{2}\ a^2\,c_0\,\sin^2 a\,\vartheta \ = \text{Konst} \dots 11.$$

erhält, weil $\cos^2 a\,\vartheta + \sin^2 a\ \vartheta = 1$ ist.

Diese Gleichung ist vollständig identisch mit der Energiegleichung schwingender Bewegungen, u.zw. ist die Uebereinstimmung nicht nur formal, sondern sie erstreckt sich auch auf das Wesen der Dinge. Aus einer so weitgehenden Uebereinstimmung kann ohne weiteres bloss auf Grund der Analogien schon dieser Schluss gezogen werden, dass die periodische Aenderung des photosynthetischen Vorganges dieselben Gesetzmässigkeiten untergeworfen ist, wie die Schwingung selbst, d.h. dass die photosynthetische Produktion des Phytoplanktons ebenfalls durch die Sinusfunktion darstellbar ist. Dem Ausschlag der schwingenden Bewegung entspricht nämlich die Strecke $q = \sqrt{c_0}\ \sin a\vartheta$, deswegen wird auch die Grösse der photosynthetischen Produktion durch die Sinusfunktion ausgedrückt. Da diese ihr Maximum bei optimaler Beleuchtung als $a\,\vartheta = \dfrac{\pi}{2}$ und $\vartheta = \dfrac{\tau}{4}$ wird erreicht, lässt sich aus diesen Gleichungen zeigen, dass $a = \dfrac{2\,\pi}{\tau} = 2\,\pi v$, denselben Wert annimmt, wie in Gleichungen 5. und 5a. Setzt man das in 11. ein, und berücksichtigt Gleichung 5. auch, so gelangt man zu der Gleichung:

$$E = \frac{\psi\,\xi}{2}\,(2\,\pi\,v)^2 c_0\,\sin^2 I + \frac{\psi\xi}{2}(2\,\pi v)^2 c_0\,\cos^2 I =$$

Konst $\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$ **12.**

welche aussagt, dass die photosynthetische Produktion des

Phytoplanktons wahrlich die Sinusfunktion einer der Lichtstärke proportoinalen Grösse I ist, womit *ein theoretischer Beweis unserer gleichlautenden früheren Versuchsergebnisse erbracht ist.*

Aus Gleichungen 5. und 12. geht weiters noch hervor, dass die Frequenz (ν) beider Vorgänge, nämlich diese der periodischen Aenderung der irdischen Lichtstärke und der photosynthetischen Produktion des Phytoplanktons, *dieselbe ist.* Das ist eigentlich das *Kirchhoffsche* Gesetz, indem es aussagt, dass der photosynthetische Vorgang als System quasi-elastischer Kräfte, *für einen Resonator aufgefasst werden kann, welcher Eigenschwingungen von gleicher Schwingungszahl, wie die Intensität des absorbierten Lichtes selbst, auszuführen geeignet ist.*

Betrachten wir den photosynthetischen Vorgang des Phytoplanktons nach den vorherigen Ueberlägungen für ein System quasi-elastischer Kräfte, welches seinem Wesen nach einen Resonator darstellt, dann sind wir auch in diesem Falle berechtigt die auf einen Resonator gültigen Sätze anzuwenden. Sehen wir also den Impuls p $= \psi \, \xi \; a \sqrt{c_0} \cos a \, \vartheta$ und die Strecke q $= \sqrt{c_0} \sin a \, \vartheta$ als rechtwinkelige Koordinaten an, so gelangen wir zu der zentralen Gleichung der Ellipse, welche wie folgt aufgeschrieben werden kann:

$$\frac{p^2}{\left[\sqrt{2 \, \psi \, \xi \, E} \right]^2} + \frac{q^2}{\left[\dfrac{\sqrt{2 \, E}}{2 \, \pi \, \nu \, \sqrt{\psi \, \xi}} \right]^2} = 1$$

Der Flächeninhalt dieser Ellipse ist durch die Formel:

$$T = \pi \, \sqrt{2 \, \psi \, \xi \, E} \; \frac{\sqrt{2 \, E}}{2 \, \pi \, \nu \, \sqrt{\psi \, \xi}} = \frac{E}{\nu} \qquad\qquad 13$$

gegeben, was gleich der, durch die absorbierte und während der Photosynthese in den gebildeten Kohlenhydraten gespeicherten Lichtenergie entsprechende Wirkungsmenge ist. Nach der Quantenlehre soll diese eine ganzzahlige Mehrfache der elementaren Wirkungsmenge (h) sein. Sehen wir, ob das in diesem Falle auch nachgewiesen werden könnte?

Nach Gleichung 12. ist die Gesamtenergie der Photosynthese

E = Konst. Weiterhin wissen wir, dass $\nu = \dfrac{1}{\tau} = \dfrac{1}{4 \, \varkappa}$ ist.

Setzen wir das in Gleichung 13. ein, so wird:

$$\frac{E}{\nu} = 4. \; Konst. \; \varkappa$$

Multipliziert und dividiert man zugleich die rechte Seite der Gleichung durch 10^{-27}, dann ergibt sich die Gleichung:

$$\frac{E}{\nu} = n. \, 10^{-27}. \quad \varkappa = nh \; \dotsfill \quad 14.$$

wo n $=$ 4. Konst. 10^{27} ist. *Nachdem das Produkt 10^{-27} $\varkappa$ als*

logische Folge mathematischer Operationen den Platz der Plank-
schen Universalkonstante in Gleichung 14 einnimmt, dürfte es
durchaus kein Zufall sein, dass auch sein Zahlenwert binnen
den Grenzen der Versuchsfehlern fast vollständig identisch mit
demjenigen dieser berühmten Konstante ist, da die Differenz
beider Zahlen nur 1% ausmacht. Demnach entspricht der Ellip-
senfläche tatsächlich die Mehrfache der elementaren Wirkungs-
grösse, d.h.

$$T = \frac{E}{\nu} = nh \qquad\qquad 15.$$

Dieses Ergebnis weist allerdings darauf hin, dass der *Plakschen*
Konstante, die nach den Vorherigen mit dem, für optimale Be-

leuchtung geltenden Wert des Bruches $h = \dfrac{10^{-27}}{\omega^2 \sin \mu}$ identisch

ist, auch auf dem Gebiete der Limnologie *eine besondere Be-*
deutung zugeschrieben werden muss. Das ist nur auf ersten
Blick überraschend, denn wenn man bedenkt, dass die Photo-
synthese und das Licht in kausalem Verhältnis zueinander ste-
hen, und wenn man noch in Rechnung zieht, dass die Assimi-
lation ihrem Wesen nach ein Reduktionsvorgang ist, wobei
Elektronen aufgenommen werden, welche in dem molekularen
Aufbau der gebildeten Kohlenhydraten eine wichtige Rolle spie-
len, dan wird es einleuchtend, dass auch hier *die Gesetzmässig-*
keiten der modernen Atomphysik zur Geltung kommen müssen.
Der Zahlenwert des Faktors n lässt sich nun aus der Sauer-
stoffproduktion bei optimaler Beleuchtung der Phytoplankton-
algen berechnen. Die O_2 Produktion der Algen wird neuerdings
auf dem Vorschlag von MARSHALL und ORR auf 10^6 Algenzellen
und auf die Zeitdauer von 3 Stunden bezogen angegeben. Nach
den Versuchen des Verfassers macht diese Zahl bei optimaler
Lichtstärke und bei einer Temperatur von 18,6° 0,279 mg aus.
SCHOMER und JUDAY, (11) wie das aus ihren ausgewählten Da-
ten in der nachstehenden Tabelle ersichtlich ist, fanden dass
dieser Wert zwischen 0,221 und 0,413 mg schwankt. Die Unter-

Tabelle 1.

Benennung des Sees	Temperatur C°	Organismus	3 stündiger O_2 Produktion 10^6 Zellen. mg
Helmet Lake	24,9	Coccomyxa	0,298
„ „	—	„	0,413
Trout Lake	19,5	Chlorella	0,225
„ „	—	Coccomyxa	0,221
„ „	—	„	0,242
„ „	—	„	0,233
„ „	—	„	0,300
„ „	—	„	0,257

schiede stammen neben den Versuchsfehlern und Temperatur-
unterschiede gewiss auch daher, dass unter den Algen gute und
mässig gute Produzenten vorkommen. Diese Unterschiede könn-
ten mit den verschiedenen Amplituden monochromatischer
Strahlung verglichen werden. In der statistischen Mechanik
werden die verschiedene Amplituden separat nicht in Rechnung
gezogen, nur ihre Mittelwerte, da man vermuten darf, dass
beim thermodynamischen Gleichgewicht mit grösster Wahr-
scheinlichkeit die mittleren Amplituden neben einander vor-
kommen. In den Gewässern kommen recht viele verschiedene
Algen nebeneinander vor. Es ist höchst wahrscheinlich, dass
unter denen diejenigen von mittleren Produktionsfähigkeit die
Mehrzahl haben. Deswegen basieren wir unsere Berechnungen
auf den Mittelwert der Ergebnisse unserer eigenen Versuche
und dieser von SCHOMER und JUDAY. Der Mittelwert ergibt sich
zu 0,274 mg.

Wir wollen aber betonen, dass das zu erwartende Resultat
dieser Berechnung durchaus nicht für eine endgültige Zahl zu
betrachten ist, weil die Zahl der obenangeführten Versuchser-
gebnisse *viel zu klein* (9) ist, weiters beziehen sie sich *nicht
genau auf dieselbe Temperatur*. Die Berechnung des genauen
Wertes von n soll den Versuchen vorbehalten werden, die wir in
unmittelbarer Zukunft auszuführen beabsichtigt sind.

Nachdem die zur Zeit zur Verfügung stehenden meist ver-
traulichen Versuchsergäbnisse auf 10^6 Algenzellen und 3 Stun-
den bezogen im Mittel 0,274 mg O_2 Produktion liefern, lässt
sich leicht berechnen, dass ein einziges Individuum in der Se-
kunde 10^{-11} 2,54 mg O_2 entbindet, für dem die Speicherung
einer Lichtenergie von 10^{-6}3,86 Erg entspricht. (6 Molen O_2
entsprechen 685000 Grammkalorien = 10^{10} 2,92 Erg.) Setzt
man darum in Gleichung 15. statt E 10^{-6}3,86, dann erhalten
wir:

$$\frac{10^{-6}\ 3,86}{\nu} = n.\ 10^{-27}.\ 6,547\ \text{Erg Sec},$$

wovon:

$$n = \frac{10^{-6}\ 3,86}{10^{-27}.\ 6,547\ \nu}$$

Da aber $\nu = \dfrac{1}{\tau} = \dfrac{1}{4.\ 6,481}$ ist, folgt dass

$$n = \frac{10^{-6}.\ 3,86.\ 4.\ 6,481}{10^{-27}\ 6,547} = 10^{20}.\ 153$$

ist. Gleichung 15. nimmt darum die Form

$$\frac{E}{\nu} = 10^{20}.\ 153.h \dots\dots\dots\dots\dots\dots\dots\dots \quad 16.$$

an, woraus die Gleichung:

$$E = 10^{20}.\ 153.\ \nu.\ h = 10^{20}.\ 153\ \varepsilon$$

sich ergibt, welche aussagt, dass soll die Absorbtion der Licht-
energie seitens der Algen entweder entsprechend der ersten
Hypothese von PLANK in Quanten (ε), oder nach der zweiten,
kotinuierlich erfolgen, die gespeicherte Lichtenergie der gleich-
zeitig produzierten organischen Verbindungen, *kann als eine
ganzzahlige Vielfache eines elementaren Energiequantums auf-
gefasst werden.* Diese Feststellung zeigt gewiss auf eine weit-
gehende Analogie hin, die zwischen den photosynthetischen Vor-
gang des Phytoplanktons und der Strahlungsenergie besteht.
Allerdings ist das verständlich, da die Strahlungsenergie der
Sonne und die Photosynthese im engen kausalen Verhältnis zu
einander stehen.

In den Vorhergehenden wurde also durch Anwendung einiger
Lehrsätze der modernen Physik theoretisch auch bewiesen, dass
die auf empirischem Wege bereits früher gemachte Beobachtung
des Verfassers, wonach die photosynthetische Produktion des
Phytoplanktons wahrlich die Sinusfunktion einer der Licht-
stärke proportionalen Grösse ist. Dadurch erhielten auch die
Voraussetzungen, welche wir zur Erklärung der Sauerstoff-
schichtung in den Gewässern und der regionalen bzw der verti-
kalen Verteilung des Phytoplanktons machten, eine theoretische
Bestättigung. Es geht aus unseren Untersuchungen auch hervor,
dass der PLANKSCHEN Universalkonstante eine entsprechende
biologische Bedeutung zugeschrieben werden muss. Schliesslich
ergab sich, dass der photosynthetischer Vorgang und dadurch
vermittelt das biologische Geschehen im oceanischen und lim-
nischen Lebensraume als ein Resonator aufgefasst werden kann,
welcher dem KIRCHHOFFSCHEN Gesetz untergeworfen ist, d. h
die Frequenz seiner Eigenschwingung, auf die Periodizität der
Intensitätsschwankungen des Sonnenlichtes gestimmt ist, dem-
nach eine Funktion des Rhythmus' des Sonnensystems ist. Bis
wir den endgültigen Wert von n experimentell nicht festgestellt
haben, wollen wir vorläufig keine weitere Schlüsse aus den
obenangeführten Versuchsergebnisse ziehen, doch führen wir
noch eine Berechnung an, da diese anscheinend eine Orientie-
rung darüber zu liefern geeignet ist, inwieweit unsere Darle-
gungen mit der Erfahrung übereinstimmen?

Deswegen greifen wir auf Gleichung 4. zurück und schreiben
diese jetzt folgenderweise auf:

$$I = 10^{27}.\ h\ \frac{n}{\varkappa}.\ \frac{\pi}{2} = 4.\ 10^{27}\ h.\ n.\ \nu\ .\frac{\pi}{2}$$

da man $\varkappa$ statt die Grösse $10^{27}.\ h.$ weiters statt $\omega^2 \sin\ \mu = \dfrac{n}{\varkappa} =$

$\dfrac{\overline{n}}{4} = 4 \, n\nu$ setzen darf. Vergleicht man diese Gleichung mit 17.

und setzt optimale Beleuchtung voraus, wann also n $=$ 1 ist, so folgt, dass

$$I = 4. \, 10^5 \, \frac{1{,}5708}{1{,}53}. \, E = 10^5. \, 4{,}104. \, E$$

ist. Denkt man sich die beleuchtete Hälfte der Oberfläche von den Algen in einer Ebene ausgebreitet, so lässt sich aus der letzten Gleichung schliessen, dass bei optimaler Beleuchtung die Lichtenergie der Sonnenstrahlung zur Aufrechterhaltung des Assimilationsvorganges von 10^5. 4,104 Individuen geradezu ausreicht, da auf einer Fläche von 1 cm^2 soviel Individuen Platz finden. Die Lichtintensität wird nämlich auf 1 cm^2 Fläche angegeben, wobei in diesem Falle die Dimension der angewandten Einheit keine Rolle spielt. Daraus lässt sich nun Berechnen, dass die Hälfte der Gesamtkörperoberfläche der Algen

$$\frac{1}{4{,}104. \quad 10^5} = 10^{-6}. \, 2{,}44 \text{ cm}^2$$

ausmacht, wovon der mittlere Halbdurchmesser der Algen, wenn man diese sich kugelförmig vorstellt zu

$$\varrho = \sqrt{\frac{2.10^{-6}. \quad 2{,}44}{4 \, . \, \pi}} = 10^{-4}. \, 6{,}23 \text{ cm}$$

d. h. zu 6.23 μ sich berechnen lässt. Die Hydrobiologen wissen, dass diese Zahl den wirklichen Verhältnissen recht nahe steht. Das dürfte ein Beweis dafür sein, dass unsere Bedenkungen mit der Erfahrung gut übereinstimmen.

Literaturverzeichnis

1. D o r n o, C.: Licht und Luft des Hochgebirges. Braunschweig. 1911.
2. F i c k.: Pogg. Ann. 94, 59. Nach C h w o l s o n: Lehrbuch der Physik. I. 629. 1902.
3. M a r s h a l l, S. M. and O r r, O. P.: The Reaction of the Plankton to some chemical and physical Factors in the Clyde Sea Area. Journ. of the Marine Biological Association of the United Kingdom. XIV. 637. 1927.
4. —— —— ——: The Photosynthesis of Diatom Cultures in the Sea. Ibid. XV. 321, 1928.
5. M a u c h a, R.: Upon the Influence of Intensity of Light and Temperature on the photosynthetic Production of Nannoplankton. Verhandl. d. Internat. Ver. f. Limnologie. II. 381. Innsbruck. 1924.
6. —— ——: Einige Bemerkungen zu der Arbeit von F. Ruttner (Lunz): „Ueber die Kohlensäure Assimilation einiger Wasserpflanzen in verschiedenen Tiefen des Lunzer Untersees. Internat. Rev. d. ges. Hydrob. u. Hydrogr. XVIII. 388. 1927.
7. —— ——: Ueber einige kosmische Faktoren der Phytoplankton-Produktion. Arch. f. Hydrob. XXXII. 434. 1937.
8. —— ——:Das Gleichgewicht des limnischen Lebensraumes. Arch. f. Hydrob. XXXIX. 1942.
9. N e r n s t und B r u n n e r: Zs. f. physik. Chemie. XLVII. 47. 1904. Nach E. E i c h w a l d u. A. F o d o r. Abderhaldens Handbuch der biologischen Arbeitmethoden. IX. 536.
10. R u t t n e r, F.: Ueber die Kohlensäure Assimilation einiger Wasserpflanzen in verschiedenen Tifen des Lunzer Untersees. Internat. Rev. d. ges. Hydrob. u. Hydrogr. XV. 1. 1926.
11. S c h o m e r, H. A. and J u d a y, Ch.: Photosynthesis of Algae at different Depths in some Lakes of northeastern Wisconsin. I. Observations of 1933. Transactions of the Wisconsin Akademy of Sciences, Arts and Letters. XXIX. 173. Madison. 1935.
12. S u c h l a n d t, O. und S c h m a s s m a n n, W.: Limnologische Beobachtungen an acht Hochgebergsseen der Landschaft Davos. Separatum. Zc. f. Hydrologie. VII. Heft 1—2. 1935.

On the Bohemian Species of the Genus Pedalia Barrois

by

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All appertainings of the genus Pedalia BARROIS (syn.: Pedalion HUDSON) live in the litoralplancton of various water basins during the summer, especially in July and August. The study of these species is very attractive, because of the six long and very active moving arms, which all of them are moved by means of very well developed striped muscles.

The regular and quiet swimming by means of the wheel organ, by which action the large ventral arm is always horizontally stretched, is from time to time interrupted by a violent jerking jump, resulting from the abrupt and simultaneous contraction of all arms, in the first place of the large central arm.

By preservation with formaline the bodies of all Pedaliaspecies do not change their forms and also the wheel organs keep their previous shape. This is a very exceptional fact for the armourless Rotifera. According to my experiences the preservation with formaline of Pedalia-material has only an unfavourable influence on the conservation of the former reddish staining of the end of the body.

While observing living or recently preserved individuals of the genus *Pedalia* I saw that the outline of the oesophagus was definitely carmine red.

After the preservation the colour slowly changes into light brown. After a long time it gradually turns pale and finally is fully extracted by the preserving liquid. It is very interesting indeed that all the authors who studied the living or very recently preserved material of the Pedalia remember the red colour of the anterior end of this genus, but that this staining is not related by the authors who studied material which had been preserved since a long time.

In the literature which I consulted on the Bohemian Rotifers, the discovery of some Pedalia species has not been mentioned. But, according to oral communications by some Bohemian hydrobiologists, they observed individuals of Pedaliaspecies in various Bohemian waters. Only SOUDEK and later BAYER and BAJKOV recorded *Pedalia mira* from the ponds near Lednice (Lohovecky-, Central- and Mill-ponds), South Moravia.

As the determination of all Rotifera by these authors was done according to the 14th volume of „Braun's Süsswasserfauna

(Rotatoria and Gastrotricha) it is very doubtful which species they observed.

According to the reported salinity of all ponds near Lednice, it is possible that the observed individuals belonged to Pedalia fennica, but it is not possible that all the auhors did not observe the lacking of the characteristic spined appendages on the dorsal side of the trunk, when they overlooked the lacking of the lower lip.

After a thourough investigation of the material collected by me at various places of Bohemia and after the investigations made by Mr. Doc Dr. O. JIROVEC and Dr. J. WEISER, who both had the kindness of lending me their material, I reported five species of the genus *Pedalia* in Bohemian waters. Three of those species differ so considerably from the six species which were known up till now, that they may be considered as new for science. They are Pedalia reducens n.sp., Pedalia propinqua n. sp. and Pedalia mollis n. sp.

The other two species were: *Pedalia mira* HUDSON and *Pedalia intermedia* WISZNIEWSKI.

The best and longest known species is Pedalia mira Hudson (1871). This species is distinguished by the well developed projection of the inferior wheel-circle, called „cingulum". This projection forms under the opening of the mouth a „lower lip" which falls closely over the base of the ventral arm. The second characteristic of this species are the spined appendages on the dorsal side of the trunk. Dental formula is 6/6. It is very probable that the majority of hydrobiologists, who are no specialists in Rotifers and several authors who are neither specialists described it, and that they always considered Pedalia individuals as *Pedalia mira* HUDSON.

This mistake is certainly due to the influence of Brauers's „Süsswasserfauna" which gives only one species of this genus: Pedalia mira.

Already in 1892 LEVANDER knew, that the appendages under the mouthopening of all Pedalia-individuals are not developed, that the dorsal spined appendages of the trunk may fail and that also the dental formula may have a larger index (7/7). Finally, the filamentous appendages of the ventral arm can be joined in pairs to the arm on a common socket and not single as at *Pedalia mira*. LEVANDER called this new species which is typical for brackish lakes of the inland: *Pedalia fennica*.

Living in brackish waters, lacking of the lower lip, dental formula 7/7 and the joined filamentous appendages of the ventral arm are marks which the Pedalia fennica has in common with a species described and figurated already in 1854 by SCHMARDA, in his paper: „Zur Naturgeschichte Aegyptens".

Schmarda called the species *Hexarthra polyptera*. Only the size $(0.8\ \mu)$ and Schmarda's statement that the 3 pairs of arms are ventral make this species different.

As for the thorns on the central parts of all arms, which Schmarda illustrates and describes, they could very probably be the result of a wrong observation, made on living and very active moving individudals. It is however possible, that Schmarda observed under the microscope individuals, who had soms marks in common with the individuals of *P. reduscens* n. sp. This species has on all arms the spined appendages instead of the filamentous ones. The difference between these two species is he fact that at the individuals of P. reducens n. sp. all appendages of the arms are spineshaped but at Hexarthra polyptera only the proximal appendages are spineshaped. Presently we know only one species *Pedalia bulgarica* Wisz. where one spine is developed on the dorsolateral arms on each flank before the normal filaments.

Very often at P. reduscens n. sp. and also at P. propinqua n. sp. and rarely at other species of Pedalia, I observed the preserved individuals lying upon their wheel-discs and therefore they were observed from their posterior. In these cases it really appeared that all arms arise from the ventral side of the body.

All the individuals I observed in this position concord very strikingly with the total outline on fig. 1 as Schmarda illustrates it in his work. In this case Schmarda probably gives wrong characteristics of the parts of the body. It appears that Schmarda considered the superior part of the swimming individual as the dorsal side. In this case indeed all arms are ventral. It is very probable that SCHMARDA's *Hexarthra polyptera* is no other than LEVANDER's *P. fennica*, that CLAUS in 1895 had already in his mind.

Afterwards HUTCHINSON reported in 1933 *P. fennica* in the brackish lakes of South Africa.

According to indirect information (original works are unaccessible to me) on the form captured and described by DADAY from Transsylvania and which he identifies with Hexarthra polyptera, this species must also be Pedalia fennica. The character of the locality where Daday found this species (a brackish lake in Transsylvania) confirms this opinion.

In 1903 Zernov described from brackish lakes of Central Asia: Pedalia oxyuris. This species corresponds in all characteristic marks with Pedalia fennica, from which it only differs in the development of an odd long sabreshaped cuticular appendage on the posterior end of the trunk. This projection is not common to the lacking dorsal spined appendages of P. mira. Now the species of ZERNOV is supposed to be only a variety of P. fennica.

In 1908 Daday described, also from Central Asia, a species of the genus Pedalia under the name of Pedalia mucronata; but already in 1910 HARRING identified it with the species of ZERNOV; it is also Pedalia fennica var. oxyuris Zer.

Wiszniewszki described in 1929 a third species of Pedalia

from the neighbourhood of Warszawa. According to Wisz-
niewski this species is a sort of intermediate form between
both first known species.

It corresponds to P. mira in the development of the dorsal
spined appendages of the trunk; it corresponds to P. fennica
in the lacking of the lower lip. The dental formula is smaller
than the one of both precedent species, it is only 5/5.

The filamentous appendages of the ventral arm are single
with exception of the two terminals; in this characteristic the
new species, P. intermedia, approaches to P. mira.

In 1932 de Beauchamp described from Africa the fourth
species of Pedalia, called P. jenkinae. This species lacks the
lower lip and also the dorsal spined appendages of the trunk.
The arms are very short. The dental formula is much higher
than that of all other known species: it is 9/9—10/10. The
author stresses the fact that the filamentous appendages of the
dorsal arm are not in pairs. This species probably belongs to
the group of Pedalia fennica.

A year later (1933) Wiszniewski described the fifth species
of this genus. He called it Pedalia bulgarica according to its
origin. This species also belongs to the group of P. fennica,
from which it differs by the smaller number of teeth in the
dental formula 6/6 and by the number of the filamentous ap-
pendages on all their six arms.

W. presumed that all forms of P. fennica registrated by the
various authors who observed the freshwaters of hills and
mountains (Alps, Balcan, Caucasus) are identical to this new
species.

From the material collected by the Dutch Sunda-expedition
from the freshwaters of Java, Hauer described in 1938 the
sixth species of P. called Pedalia insulana. This species posses-
ses the dorsal styliformed spinal appendages of the trunk-end,
but it lacks the lower lip. It also belongs to the group of P.
intermedia with which it agrees also in the dental formula
5/5; but it differs from it in the number of filamentous appen-
dages on the singular arm, as well as in the total length of the
body. It is very small, the length is only 100 μ.

Out of three new species of Pedalia from the Bohemian wa-
ters, P. reducens n. sp. is a new member of the group of P. mira.
Pedalia reducens corresponds to P. mira in the development of
the lower lip, and also in the dental formula. The lateral appen-
dages of the large ventral arm are single, but they are not fila-
mentously developed. They are always developed into long or
short spines.

Pedalia mollis n. sp. is striking with its very fine cuticula,
with the thin filaments of the arms. It lacks the lower lips and
also the dorsal spined appendages of the trunk. It therefore
belongs to the group of P. fennica, but it differs from this spe-
cies in its dental formula, which is smaller (only 6/6) and in

the filamentous appendages of the arms. They are not in pairs, but joined singly to the ventral arm.

The last new species, P. propinqua, cannot be classed with any other group of the genus Pedalia. It forms a fourth new group of this genus. It forms also an intermediate between P. mira and P. fennica, but in another direction as P. intermedia. The new species corresponds to P. intermedia in the dental formula, which is 5/5. With P. mira the new species has in common the development of the lower lip and with P. fennica the lacking of the dorsal spined appendages of the trunk. The new species approaches to Pedalia mira in the way of the development and the joining of the filamentous appendages of the ventral arm.

All species of the genus Pedalia can be divided into four groups. The characteristiscs of these groups are shown in the following schedule:

Schedule of groups of genus Pedalia

Characteristics of group	lower lip	Stylate appendages	species belonging to the group
I group: *Mira*	devel	devel.	P. mira, P. reducens n. sp.
II group: *Propinqua*	devel	lack.	P. propinqua n. sp.
III group: *Intermedia*	lack.	lack.	P. intermedia, P. insulana
IV group: *Fennica*	lack.	devel.	P. fennica, P. fennica var. oxyuris, P. bulgarica, P. mollis n. sp. P. jenkinae

For an exact determination of a species of the genus Pedalia it is always necessary to make sure of the following characteristics in this succession:

1⁰ Presence or lacking of dorsal spined appendages on the trunk-end.
2⁰ Presence or lacking of the lower lip.
3⁰ Dental formula.
4⁰ Single or paired insertion of the lateral appendages of the large ventral arm.
5⁰ filamentous or spined development of all arms.
6⁰ Number of spines and filaments on each arm.

According to my observations on all Pedalia-species, I know

the ventral arm normally possesses 14 appendages. The two terminal appendages of the ventral arm always sit on a common socket.

On each flank of the ventral arm there are also six appendages. With the first three Pedalia-groups they are single, but with the majority of the species of the fennica-group they are paired. From these six pairs of lateral appendages the one up to three proximal pairs of appendages are spineshaped, the following are filamentous. Only at P. reducens n. sp. all appendages are spineshaped. The filamentous appendages show short and slightly visible stripes, but the spineshaped appendages are always smooth, only the undulating outline of these spines at some individuals of P. reducens n. sp. remind of these lateral undulations At the individuals of Pedalia reducens n. sp. the shortening of the spines and the reduction of the terminal appendages occur closely together. At all Pedalia-species the number of the lateral appendages decrease from 9 to 6 filaments. With the exception of P. reducens n. sp. and P. bulgarica, they are always filamentous. At various arms the dorsal arm has 3 to 8 appendages.

They are, with the exception of P. reducens n. sp. filamentous. They are single or in pairs.

Through the kindness of Mr. Doc. Dr. O. JIROVEC I had also the occasion to see the individuals of P. insulana. From the different Bohemian localities I knew P. mira and P. intermedia. I only know P. fennica, P. bulgarica and P. jenkinae from the original descriptions and illustrations, but I never had the occasion of seeing real individuals.

A key for determining the species of the genus Pedalia Barrois.

1. Trunk with 2 dorsal appendages 2
   Trunk without 2 dorsal appendages 5
2. With lower lip under the mouth opening upon the
   large ventral arm 3
   Without lower lip 4
3. Body large (over 300 μ) lateral appendages of all arms
   are in majority filamentous. Dental formula 6/6 ... mira.
— Body small (under 200 μ). Lateral appendages of all
   arms are spineshaped. Dental formula 6/6 ...... reducens.
4. Body large (about 300 μ) Ventral arm has 3 pairs of
   spines and 8 filaments. Dental formula 5/5 ... intermedia.
— Body small (about 100 μ). The ventral arm has 3 pairs
   of spines and 8—10 filaments. Dental formula 5/5
   .... insulana.
5. With lower lip under the mouth-opening. Dental for-
   mula 5/5 .... propinqua.
   Without lower lip under the mouth-opening 6
6. Dental formula high: 9/9 or 10/10. Body small (about

Bartoš Emanuel:

The key for determinating the species of the genus
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4. Body large (about 300μ). Ventral arms has 3 pairs of spines and 8 filaments. Dental formula 5/ .... intermedia
— Body small (about 100μ). The ventral arm has 3 pairs of spines and 8—10 filaments. Dental formula 5/5 ...... insulana
5. With lower lip under the mouth-opening. Dental formula 5/5
propinqua
— Without lower lip under the mouth-opening 6
6. Dental formula high: 9/9 or 10/10. Body small (about 100μ). All arms strikingly short .... jenkinae
— Dental formula smaller: 6/6 or 7/7 7
7. Filamentous appendages on each flank of ventral arm are simple. Dental formula 6/6 .... mollis
— Filamentous appendages on flanks of ventral arm are paired 8
8. Dental formula 6/6. Ventral arm with 3—4 pairs of spines and 10—12 filaments .... bulgarica
— Dental formula 7/7. Ventral arm with 4 pairs of spines and 8 filaments 9
9. The trunk-end with a long sabreshaped cuticular appendage
fennica var. oxyuris
— Without sabreshaped appendage on the trunk .... fennica

Table of characteristical signs of all Pedalia species

Characteristical signs:
devel. = developed
lack. = lacking
s = as spine ⎫ developed
f = as filament ⎭
1 = single
2 = paired

Groups of Pedalia species and singular species

Characteristical signs	I. Group Mira				II. Group Propinqua				III. Group Intermedia						IV. Group Fennica					
	mira		reducens		propinqua		inter-media		insulana		fennica		oxyuris		bulgarica		jenkinae		mollis	
spined appendages	devel.		devel.		lack.		devel.		devel.		lack.		lack.		lack.		lack.		lack.	
lower lip	devel.		devel.		devel.		lack.		lack.		lack.		lack.		lack.		lack.		lack.	
teeth in one jaw	6		6		5		5		5		7		7		6		9–10		6	
single or paired lateral appendages on ventral arm	1		1		1		1				2		2		2		?		1	
spines and filaments	s	f	s	f	s	f	s	f	s	f	s	f	s	f	s	f	s	f	s	f
ventral arm	8	6	14	—	—	8	—	8	6	10–12	8	8	8	8	6–8	10–12	4		4	10
ventrolateral arms	9	—	9	—	—	9	—	9	—	9	—	8–9	—	8–9	—	7	—	6–8	—	9
dorsolateral arms	9	—	9	—	—	9	—	9	—	8	—	7	—	7	2	6	—	6–8	—	9
dorsal arms	8	—	3	—	—	6	—	6–7	—	7	—	8	—	8	—	*5–7	—	4	—	6

*) The great number 7 signifies, that 7 filament are common.

100 μ) All arms strikingly short .... jenkinae.
Dental formula smaller: 6/6 or 7/7 7
7. Filamentous appendages on flanks of ventral arm are
paired 8
8. Dental formula 7/7. Ventral arm with 4 pairs of
spines and 8 filaments 9
9. The trunk- end with a long sabreshaped cuticular ap-
pendage .... fennica var. oxyuris.
— Without sabreshaped appendage on the trunk ... fennica.

Annotations to and descriptions of separate species:
1 Pedalia mira HUDSON (syn. Pedalion mirum HUDSON).
This species is widely spread in our ponds and other small
waterbasins. The individuals which we find in our country are
much smaller than those of other countries. They live especially
in the densely growed parts of the banks of ponds and small
pools. The females captured from July till August bear only
the summer-eggs and those captured at the end of August and
September bear their winter-eggs. In the development of lateral
filamentous and spineshaped appendages of the ventral arm I
observed a variation at this species. The number of the anterior
spined appendages, which is generally 3/3 may vary. On the
left or right flank, or on both flanks of the arm, one spine can
fall of or it can be added. In all these cases I observed that the
number of the filamentous appendages increased or decreased
at the same time and conformably, but in reciprocal sense. This
fact is also mentioned by LEVANDER (Acta soc. fen.)
The chemical reaction of the water, in which we captured
this species was as a rule basic or neutral. Only at one place it
was acid.
Localities: Hrádek at Kunratice near Prague, pH = 5,8; VII
—VIII. 1945. Seberov, pond at Kunratice, near Prague, pH =
7,2; VII. 1945; pH = 7,3; VII. 1946. Volsanák at Kunratice,
pH = 7,4; VII. 1946. Milicov at Kreslice near Prague, II. pond;
VII. 1946, pH = 7,2. Cihlarov at Narysov near Príbram, VII.
1946, pH = 8,3. Kremze, South Bohemia, Large pond, VII.
1946 pH = 7,4; VII. 1947, pH = 7,0; I. pond under railway
track, 18. VII. 1947, pH = 7,2, 17. VII. 1946 pH = 7,4; II. pond
under railway track 17. VII. 1946 pH = 7.3, 18. VII. 1947 pH
= 7,4; III. pond under railway track 17. VII. 1946 pH = 7,4.
Medenice-pond, South Bohemia (leg. Jirovec).

2. Pedalia reducens n. sp.
In the material from Kremze, South Bohemia, lended to me
by Mr. Doc. Dr. O. JIROVEC, I found a large amount of small
individuals of the genus Pedalia. All these individuals corres-
pond with P. mira in the development of the lower lip, of the
dorsal spined appendages of the trunk, and in the dental for-
mula. But they are different in the size of the body and espe-

cially in the quality of the lateral appendages of their six arms. At the typical individuals of P. mira these appendages are long and filamentous, with the exception of the three proximal pairs of the ventral arm. Each filamentous appendage has on both flanks short spinelike stripes. But, at the individuals I observed, only the spineshaped appendages are developed instead of the filamentous appendages.

The slight stripes were always absent. With most of the individuals the spines are direct and smooth on their surface, but with some of them the surface of the spines was undulated. These undulated protractions were visible on the places of the slight stripes.

Description of P. reducens n. sp.   (Fig. 1. A—K).

The body is small, it is 110—160 μ. The body-cuticula is stiff. The wheel-organ is well developed. The internal circle (trochus) is composed of four distinct lobes that bear large and stiff whirl-ciliae. The second, external circle (cingulum) comes lower
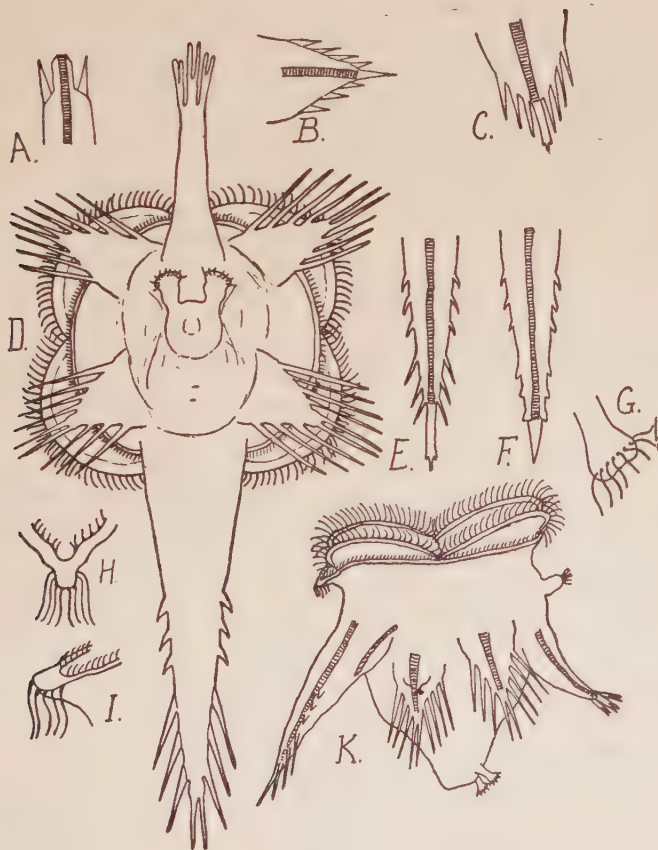
Fig. 1

than the former one and is sligthly marked out. The cingulum forms a large projection over the base of the ventral arm. This projection, called lower lip, is grown on its lateral margins with short ciliae. At the top of this projection however, we see a brush of a few long and stiff ciliae. The central part of the lower lip is deepened and leads to the oral cavity. The dorsal sense-organ is very well visible; it forms a cylindrical ascent, sharply limited from the surrounding surface of the body. The dorsal organ has on its culmination a brush of short sensorial ciliae. The lateral sense-organs are placed on the extremities of both ventro-lateral arms.

These lateral organs are very well developed, hemispherical in size and each of them has on its highest top a brush of long tactile ciliae. The spined appendages at the end of the dorsal side of the trunk are very well developed. They have long ciliae, which form a circle on each spined appendage, surrounding a slightly dilated top of each appendage.

The place of the arms is normal, the lenght of the arms is in proportion with the length of other known species, except Pedalia jenkinae. There is no difference in size and form between the proximal and distal spines of the ventral arm.

This brings me to the conclusion, that the anterior spines on the ventral arms of other species of this genus are only reduced filaments. I was brought to this conclusion also by the fact that in case of an increase of the number of arm-spines, the number of filaments diminishes and vice versa. It is possible that other authors (f. i. LEVANDER) will indicate similar observations.

The ventral arm has 14 spines. The two terminal spines are always sitting on a common socket.

The ventrolateral and dorsolateral arms have each 9 spines, from which also the terminal ones sit on common sockets. On all the lateral arms three spines are on the anterior (ventral) margins and four spines on the posterior (dorsal) margins of the arms.

Very often, at the short spined individuals, there is only one terminal spine on the tips of all six arms, instead of two. Very often intermediate forms between these two extremes can be observed (See fig. 1C and E).

The dorsal arm has always three sockets with spines. In most cases each from these three sockets end with two stump spines, but at individuals, which have only short spines on the other arms, these sockets have only one spine.

The dental formula is 6/6. The teeth diminish and gradually grow smaller from the anterior to the last one.

The males and the winter eggs have not been observed.

The plancton, which contained this new species, was collected on 17—VII—1938 by Mr. O. Jirovec. The chemical reaction of the water has not been determined. The locality was Kremze, South Bohemia. In the material from the pond of Medenice,

South Bohemia, which Mr. Doc. Dr. O. Jirovec was so kind to lend me, I observed some individuals of the species, which bear the undulated spines.

All the individuals of this new species can be divided into 4 groups, according to their size and the form of the spines on all arms.

The first group is formed by the longest individuals. Here the appendages of all arms are very long and undulated. The length of the spines on singular arms of all groups can be seen in the following schedule. To the second group belong also the longest spined individuals, but here the spines of all arms are smooth, direct and without undulations. The third group is formed by individuals whose spines are short, but who still have the complete size and a complete number of spines.

In the fourth group we find individuals with very reduced spines on the arms and with a reduction of the number of the spines on all arms. The spines are mostly tooth-shaped.

Table of lengths of arm-spines by **P e d a l i a   r e d u c e n s** n. sp. in μ

up of individuals:	I.		II		III.		IV.	
pendages:	lateral	termi-nal	lateral	termi-nal	lateral	termi-nal	lateral	termi-nal
tral arm	35—40	20—25	33—35	18—20	15—18	10—12	6—8	2—4
trolateral arm	40—45	25—30	35—40	20—25	18—22	11—14	7—10	4—5
solateral arm	35—40	20—25	30—35	18—20	15—18	8—12	6—8	3—4
sal arm	25—30	15—20	20—25	13—18	12—15	6—9	4—6	2—3

3. *Pedalia propinqua* n. sp. (fig. 2. A—D)

In the planctonsample, which Mr. Dr. J. Weiser was so kind to lend me and which he fished in a small pond near Chotebor, East Bohemia, I observed several individuals of another Pedalia-species, which only corresponds to Pedalia mira by the development of the lower lip and in the single filaments of the ventral arm. These individuals approach to P. fennica in the lacking of the dorsal spined appendages on the trunk, but it differs from Pedalia fennica by the already recorded single filaments of the ventral arm and also by the dental formula which is 5/5.

Only with this dental formula the new species approaches to Pedalia intermedia, with which it also forms an intermediate form between. P. mira but in another direction as P. intermedia. P. intermedia lacks the lower lip and possesses the dorsal spined
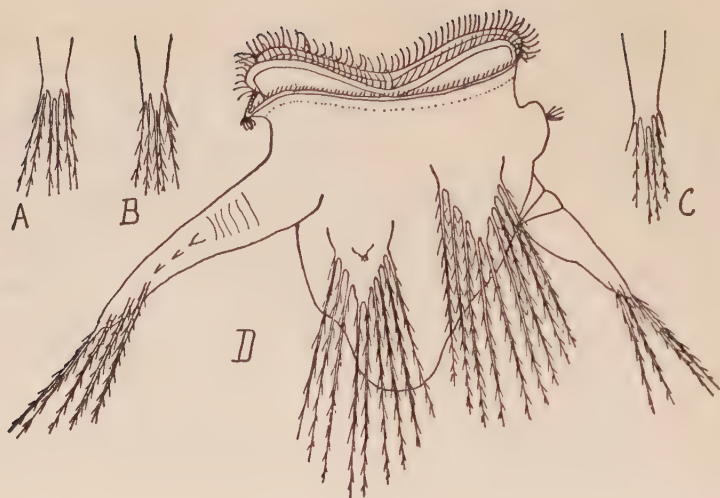
Fig. 2

appendages on the trunk as P. propinqua n. sp. lacks these appendages and possesses the lower lip.

Description of *Pedalia propinqua* n. sp.

The body attains 175—190 μ. The cuticula of the body is stiff. The wheel-organ is composed of two whirl circles. One of these, the internal circle, trochus, forms four large lobes and has long and stiff ciliae. The reddish eyes can be seen quite well. The lower lip, cingulum, comes over the base of the ventral arm in a projection. On the tip of this projection there is a brush of stiff, long, and slightly waved ciliae. The lateral margins of the lower lip are grown with shorter and finer ciliae. The central hollow part of the lower lip conducts to the oral cavity.

The dorsal sense organ is very well developed. It is located near the base of the dorsal arm. It is large, cylindrical, and it bears on the top very few ciliae. The lateral tasters are situated on the ventrolateral arms.

The end of the trunk forms two low projections, which run parallelly from the dorsal side of the trunk. They are visible only at the dorsal or ventral view of the trunk.

The large ventral arm has on each flank three spines and three filaments on a common socket, which is the same at P. mira and the other species of this genus I observed. Each of the four lateral arms has 9 filaments, from these the two terminal ones sit on a common socket. The ventral margin of each has three and the dorsal margin four filaments, the dorsal arm has six filaments, the two terminal ones always sit on one socket. The extreme filament on the left or on the right side, or sometimes on both sides, often can be shortened, or they can be developed into spines. (fig. 2 A—C) The length of the filaments are:

Arm:	ventral	ventrolateral	dorsolateral	dorsal
lateral filaments:	110	140	130	110
terminal filaments:	80	120	115	80

The dental formula is: 5/5. The teeth from the anterior to the last grow gradually smaller.

This species was accompagnied by *Keratella quadrata* f. *dispersa* CARLIN (very often), Keratella stipitata f. macracantha LAUT. (very often), Keratella valga EHRBG (rare), Brachionus capsuliflorus v. Melhemi BARR & DADAY (rare), Br. calicyflorus f. dorcas GOSSE (r), Polyarthra euryptera WIERZ (often), Trichocerca cylindrica IMHOF (r), Colurella bicuspidata EHRBG (v.r), Noteus militaris (EHRBG) (v.r), Ploesoma hudsoni IMHOF (v. r.).

Locality: Chotebor, pond near a kiln of bricks 15, VII, 1940. Temp. 26,5 C.; pH 7,2; transparence of the water: 35 cm.

4. *Pedalia intermedia* WISZNIEWSKI.

This species was found in the plancton Mr. doc. O. JIROVEC and Dr. J. WEISER kindly lent me.

The individuals of this species attain 175—185 μ. The ventral arm of our individuals always has two terminal filaments on a common socket. The dorsal arm has 6—7 filaments. From these the two or three terminals are also on a common socket. Each lateral arm bears 9 filaments. The lateral appendages sit on a common socket, in this way on three sockets. The filaments are disposed as at P. propinqua or P. mira and other species of this genus, which have 9 filamentous appendages.

Localities: New pond near Sobeslav and Humlensky-pond, both in South Bohemia and both fished by Mr. doc. Dr. O. JIROVEC. Pool near the Kacir-pond on the Bohemian--Moravian hills, fished by Mr. Dr. J. WEISER.

5. *Pedalia mollis*. n. sp.

I detected this species in the same planctonsample as Pedalia reducens n. sp. in the material lended to me by Dr. O. JIROVEC, fished at Kremze, South Bohemia.

This species differs from Pedalia mira in the lacking of the dorsal spined appendages of the trunk and also in the lacking of the lower lip. It corresponds to Ped. mira only in the dental formula and in the single filamentous appendages of the ventral arm.

Description of Pedalia mollis n. sp. (fig. 3.)

The length of the body is 180—200 μ. The cuticula of the body is very thin and it is probably a little slimy, therefore most of the individuals were glued together in the studied planctonsamples.

The wheel-organ consists of two whirl circles. The inner
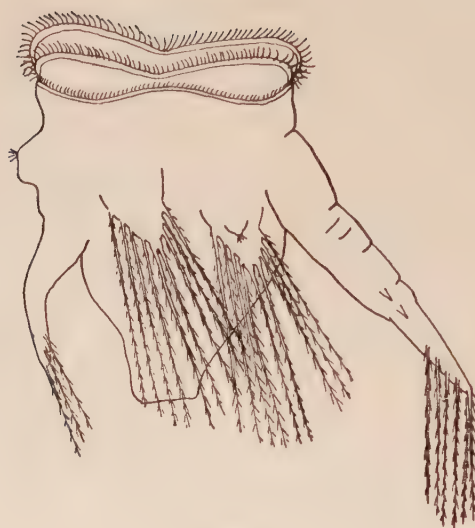
Fig. 3

circle, trochus, has four lobes. The outer circle, cingulum, is slightly developed and does not form any projection or lower lip. The dorsal tentacle is very well developed. The lateral tentacle sit on the ventrolateral arms. From the six arms the ventral arm is very stout, the dorsal arm is slender. The ventral arm has on each flank proximally two teeth and distally four filaments. On its tip two terminal filaments sit on a common socket. The lateral arms, especially the dorsolateral arms sit very high on the body. Each of them bears 9 filaments, similarly arranged as at Ped. mira an Ped. propinqua. The dorsal arm has 6 filaments on three sockets.

The length of the filaments are:

	ventral arm	ventrolateral arm	dorsolateral arm	dorsal arm
lateral filaments	95	132	130	92
terminal filaments	68	112	110	71

Dental formula: 6/6. The three anterior teeth are much thicker than the three posterior ones. Between the anterior and the posterior teeth there is no gradual passage.

Localities: Kremze, South Bohemia, (fished by Doc. Dr. O. J. JIROVEC). Volsanak-pond at Kunrotice near Prague (fished by BARTOS in July 1946. pH : 7,4.

Literature.

BARTOS, E., 1947. Virníci ceskych vod. — The waterdwelling Rotatoria of Bohemia. Vest. Csl. zool. spol. Vol. 11.

BAYER A BAJKOV, 1929. Hydrobiologická studia rybniku lednickych. I. Vyzkum heloplanktonu a jeho pomeru quantitativních. Bull. de l'école sup. d'agronomie, Brno, CSR. Sign. D 14.

BEAUCHAMP, P. DE, 1932. Reports on the Percy Sladen Expedition to some Rift Valley Lakes in Kenya in 1929. — III. Rotifères des Lacs de la Vallée du Rift. Ann. & Mag. Nat. Hist. X. Ser. 9. Vol.

BRAUER, 1912. Süsswasserfauna Deutschlands. Hft. 14. Rotatoria und Gastrotricha. Jena.

CARLIN, B., 1945. Våra planktonrotatorier. Medlemsblad for biologilärarnas förening. Vol. I.

CLAUS, C., 1899. Bemerkungen über Pedalion mira Hudson. Arbeit. aus d. zool. Inst. Univ. Wien. T. XI. (1895—1899).

HAUER, J., 1938. Die Rotatorien von Sumatra, Java und Bali nach den Ergebnissen der Deutschen Limnologischen Sunda-Expedition. Arch. f. Hydrob. Suppl. zu 15. Bd.

HUTCHINSON, 1932. Contribution to the Hydrobiology of pans of South Africa. Arch. f. Hydrobiol., 24.

IMHOF, O. E., 1890. Notiz über das Vorkommen von Pedalion mirum Hudson. Zool. Anz. 13.

LEVANDER, K. M., 1892. Eine neue Pedalion-Art. Zool. Anz. 15.

LEVANDER, K. M., 1894. Beiträge zur Kenntnis der Pedalion-Arten. Acta Soc. pro Fauna et Flora Fennica, 11. Nr. 1.

SCHMARDA, L. K., 1854. Zur Naturgeschichte Aegyptens. Denkschrift. Kais. Ak. d. Wiss. Wien. Math. naturw. Kl. B. 7.

SKORIKOV, A. S., 1910. Pedalion mucronatum Daday (1909) = Pedalion oxyure Zernov (1903). Zool. Anz. 36.

SOUDEK, S., 1929. Prispevek k vyzekumu zooplanktonu rybníku Lednickych. — Contribution to the Knowledge of the Zooplankton of the Ponds of Lednice. Sbonník Masarykovy akademie práce. 3.

WILLIAMS, E. G., 1941. An interesting Rotifer, Pedalion mirum Hudson. North Western Nat. Arbroath. 16. 201 (Unaccessible).

WISZNIEWSKI, J., 1929. Zwei neue Rädertierarten: Pedalia intermedia n. sp. und Paradicranophorus limosus n.g.n.sp. Bull. Ak. Pol. Sc. e. Let. Cl. Sc. Math. Nat. Ser. B. Sc. Nat. 2.

WISZNIEWSKI, J., 1931. Sur quelques rotifères trouvés en Espagne. Arch. d'Hydrobiol et d'Ichthyol. 6. Suwalki.

WISZNIEWSKI, J., 1933. Un nouveau Rotifère du genre Pedalia habitant les lacs des hautes montagnes. Int. Rev. d. ges. Hydrobiol. u. Hydrogr. 29.

Text to figures 1—3.

Fig. 1. Pedalia reducens n. sp. A-dorsal arm with three spines. B- and C-ventrolateral arms with reduced terminal spines. D-total view from below. E- and F-ventral arms with reduced terminal spines. G-dorsal stylate appendage, lateral view. H-lower lip from above. I-lower lip side view, K-total view from left side.

Fig. 2. Pedalia propinqua n. sp.; A.-C. various forms of dorsal arm. D. total view.

Fig. 3. Pedalia mollis n. sp.; total view.

A propos de quelques espèces du genre Trachelomonas Ehrbg. et du genre Strombomonas Defl. trouvées aux Pays-Bas

par. A. Middelhoek.

Je m'étais d'abord proposé de dresser la liste de toutes les espéces des genres Trachelomonas et Strombomonas que j'avais récoltées aux Pays-Bas, mais j'ai dû renoncer à mon projet initial, car la richesse du matériel m'est apparue telle que ce travail aurait pris une trop grande extension pour le moment.

Jusqu'ici W. Conrad était le seul des chercheurs néerlandais qui ait consacré une attention particulière aux genres précités. Le matériel récolté m'a fourni l'occasion d'observer que le genre Trachelomonas en particulier était intéressant par le nombre d'espèces variées et peu connues; de plus. chaque espèce était représentée par des milliers d'individus.

Il m'a donc paru utile du point de vue systématique de communiquer mes notes à ce sujet. Car il est arrivé que l'étude d'une espèce déterminée, observée d'aprés un nombre suffisant d'exemplaires et dans un milieu nettement délimité, permet de compléter ou de rectifier les données obtenues par l'observation d'un nombre restreint d' individus.

Le but que je me propose est donc de publier mon travail au cours de quelques notes successives qui donneront de la sorte un aperçu général des espèces trouvées aux Pays-Bas.

Les figures ci-jointes sont faites d'après nature, c'est à dire d'après du matériel frais et vivant. Les dessins sont originaux. Ce sont des agrandissements à 1500/1, sauf indication contraire.

Le matériel fixé, pour servir de documentation, a été envoyé au „Leids Herbarium".

En ce qui concerne la biologie générale, cf. la littérature existante.

L'examen des spécimens a été fait à de forts grossissements, de l'ordre de 840—1260 à 2940, en se servant de l'immersion à l'huile.

Trachelomonas aplanata Drezepolski.
Pl. I, ff. 1—3.
Dans sa monographie, Deflandre décrit cette espèce comme étant Trachelomonas volvocina var. aplanata. Je l'ai trouvée en grand nombre; ses dimensions étaient admirablement constan-

78
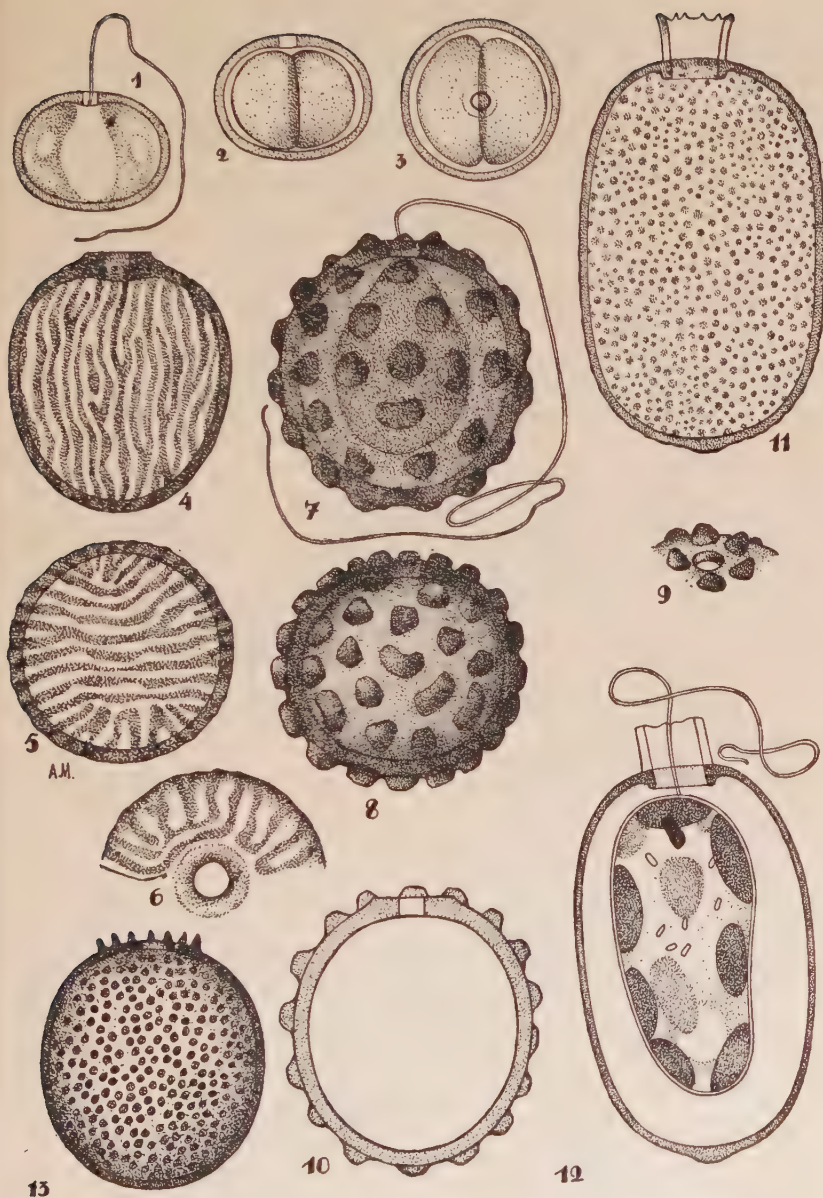
Fig, 1

tes, c. à d. long. 11 μ, larg. 14 μ, R.C. = 0,77 (Drez. 0,80).

La loge est ellipsoïdale, lisse et rouge-brun clair.

Il y a deux chromatophores avec pyrénoïde; le flagellum mesure 3 fois la longueur du corps. Bien des exemplaires étaient

au stade de la bipartition. Le plan de séparation occupe toujours une position parfaitement médiane. En vue apicale, ce plan de séparation divise la coupe optique transversale en deux parties égales fig. 3), contrairement à Trachelomonas volvocina Ehrbg. Dans cette espèce, le plan de séparation occupe une position oblique. Cette singularité, en connexion avec la forme ellipsoïdale de la loge, permet, à mon avis, de considérer la détermination de Tr. aplanata Drez. comme exacte.

Glanerbrug 24/11/45, 16/12/45, pH = 6.

Trachelomonas Stokesiana Palmer.

Pl. I, ff. 4 — 6.

Palmer décrit cette espèce dans „Delaware Valley Forms of Trachelomonas". Plusieurs auteurs la considéraient comme identique à Tr. rugulosa Stein (Deflandre 1926, Balech 1944 e.a.). Palmer décrit aussi une Tr. rugulosa de Stein, il admet la possibilité, qu'elle corresponde à Tr. rugulosa Stein. Considérons d'abord Tr. Stokesiana Palmer. Je l'ai trouvée dans les divers étangs d'Enschede par milliers d'exemplaires. Tous ressemblaient exactement à l'espèce décrite par Palmer.

Les loges sont ordinairement ovoïdes, rarement sphériques, long. 20 μ, larg. 19 μ, pore à bord épaissi avec un col très bas. La loge est munie de stries proéminentes, s'anastomosant par places, longitudinales ou un peu obliques.

Membrane relativement robuste, brun-jaune foncé ou brun-rouge foncé.

Plan de séparation un peu oblique.

Je considère cette espèce comme identique à Tr. Stokesiana Palmer.

Deflandre m'a fait savoir qu' il considère cette espèce comme déterminée avec exactitude (contrairement à ce qu'il a écrit dans sa monographie). Quant à Stein, bien qu'excellent observateur, il a laissé des dessins peu nets des espèces. Il arrive que les loges de Tr. volvocina aient l'aspect décrit par Stein pour Tr. rugulosa, c'est à dire une ornementation dûe à l'âge des individus. La forme que Stein indique n'a pas encore été retrouvée.

L'espèce que Palmer décrit comme Tr. rugulosa Stein se distingue de celle que nous fournissent les dessins de Stein, ce que Palmer fait remarquer. Il est probable que la détermination de rugulosa de Palmer soit exacte, ce qui n'empêche pas le doute au sujet de Tr. rugulosa de Stein.

Etang „'t Wooldrik" Enschede, 1946, toute l'année, pH = 4,9, Cl 53 mgr pro L, très fréquente. Etang „Minkmaat" Enschede, 1946, très fréquente.

Trachelomonas acanthostoma Stokes sensù Deflandre.

Pl. I et II, ff. 13—18.

Cette espèce se rencontre très fréquemment dans divers étangs d'Enschede, et elle est d'une grande variabilité.
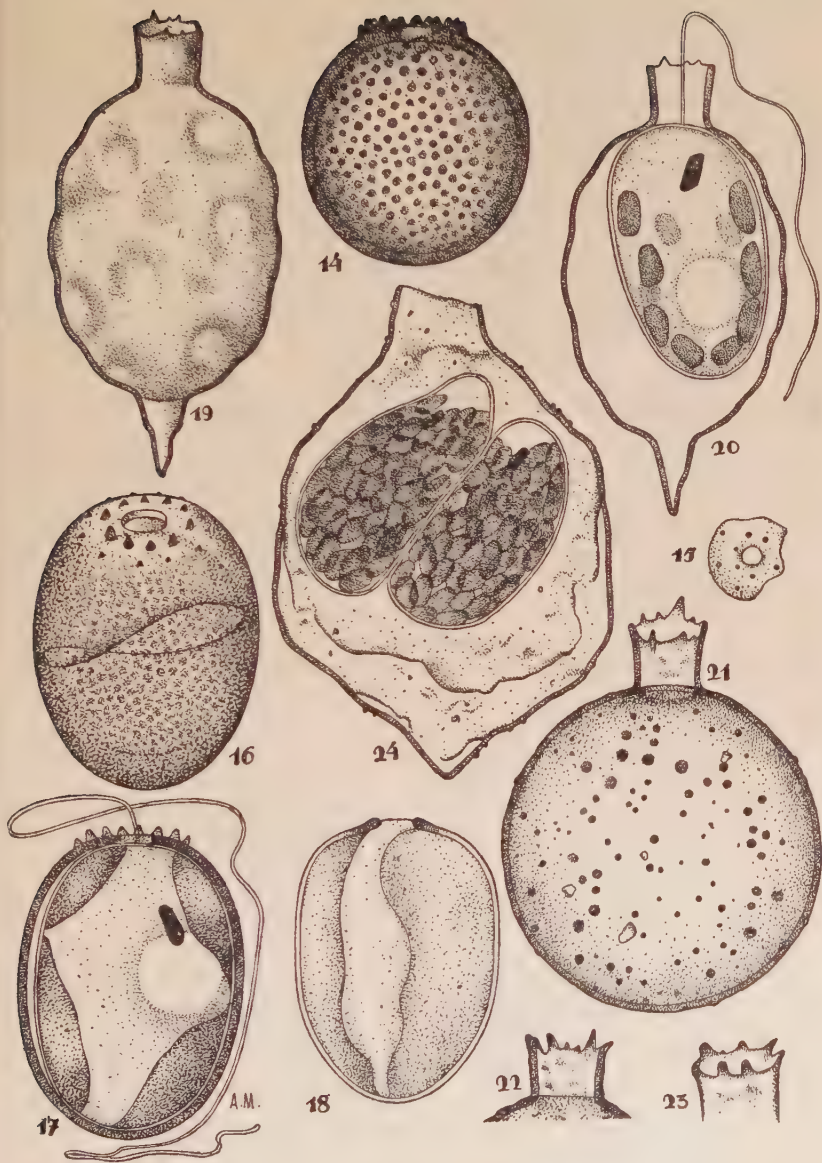
Fig. 2

J'eus l'occasion d'étudier cette espèce en de très nombreux exemplaires. La forme de la loge varie entre la sphère et l'ellipse allongée. En aucun cas je n'ai observé de col. Le pore est toujours sans un épaississement annulaire. La loge est densément ponctuée, les points sont tantôt fins, tantôt grossiers. Parfois

il y a des épines très courtes. Le pore est entouré d'une ou de deux couronnes d'épines courtes.

Le plan de séparation fait un angle de presque 90° avec l'axe longitudinal (fig. 16).

Les chromatophores sont de forme irrégulière et il est difficile d'en fixer le nombre. Un stigme est toujours présent (vide Lemmermann, Kryptogamenflora der Mark Brandenburg, pag. 523).

Long. 23—36 μ, larg. 19—22 μ.

,,'t Stokhorst" Enschede 19/2/46, pH = 6. — Ootmarsum 25/8/46. — ,,de Kolk" Enschede 16/10/45, pH = 6. — Glanerbrug 24/11/45, pH = 6.

L'espèce se meut parfois entourée d'une couche de mucilage.

Trachelomonas pseudocaudata Defl.

Pl. III, ff. 27—28.

Cette espèce se distingue nettement de Tr. caudata (Ehrbg) Stein. Elle est très fréquente aux environs d' Enschede à un pH de 5—6, et répond bien à la diagnose de l'auteur, sauf que l'épaississement annulaire est toujours absent. Il y a à cet endroit un épaississement de la membrane qui diminue graduellement vers le pôle postérieur de la loge.

La loge a une forme ellipsoîdale parfaite. Les chromatophores sont très variables. Le plus souvent on remarque 12 environ qui sont relativement grands, mais de temps en temps il y en a environ 30 de petites dimensions.

Long. ot. 38—48 μ, larg. 22—26 μ. Col large à la base de 4,5 —5 μ, haut de 4 μ, queue long. 4 μ.

L'espèce se meut aussi bien en avant qu'en arrière. J'ai pu constater le même phénomène chez Tr. oblonga Lemm.

Trachelomonas ovata Roll.

Pl. IV, ff. 29, 30.

Cette belle et grande espèce fut trouvée en un seul exemplaire dans l'étang ,,'t Stokhorst" à Enschede. L'espèce est décrite par Roll et ne semble pas avoir été observée par d'autres auteurs. La long. est de 64 μ, la larg. de 34 μ.

La membrane qui entoure le pore s'épaissit. Diam. du pore 6 μ. Toute la loge est régulièrement pourvue d'épines bacillaires extrêmement fines.

La loge est orange-brun clair.

Les chromatophores sont pariétaux, au nombre de 30 environ. Les grains de paramylum sont nombreux et dispersés dans la cellule. Le noyau est situé dans la partie basale de ce dernier. Le stigme est relativement grand. Le flagellum a environ la même longueur que la loge.

Enschede, étang ,,'t Stokhorst" 29/2/46, pH = 6.
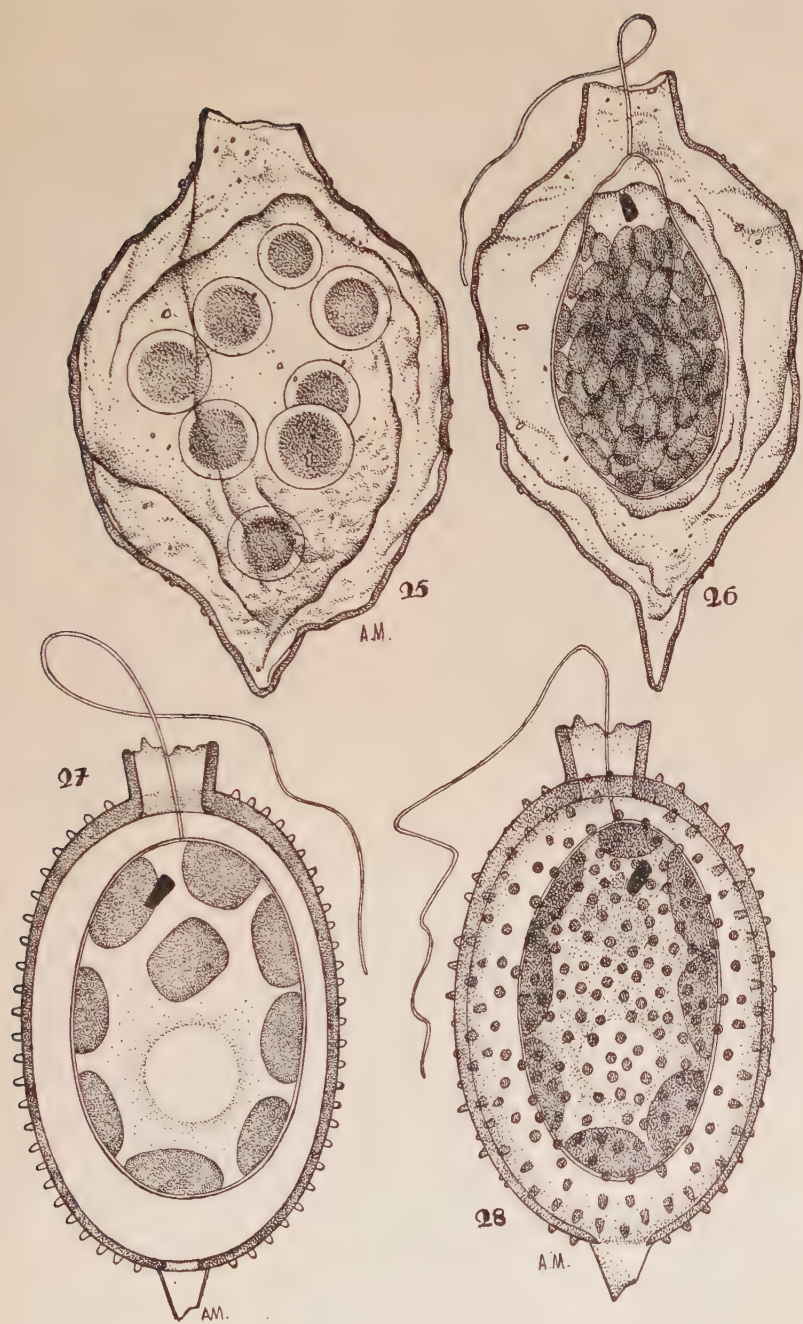
Fig. 3
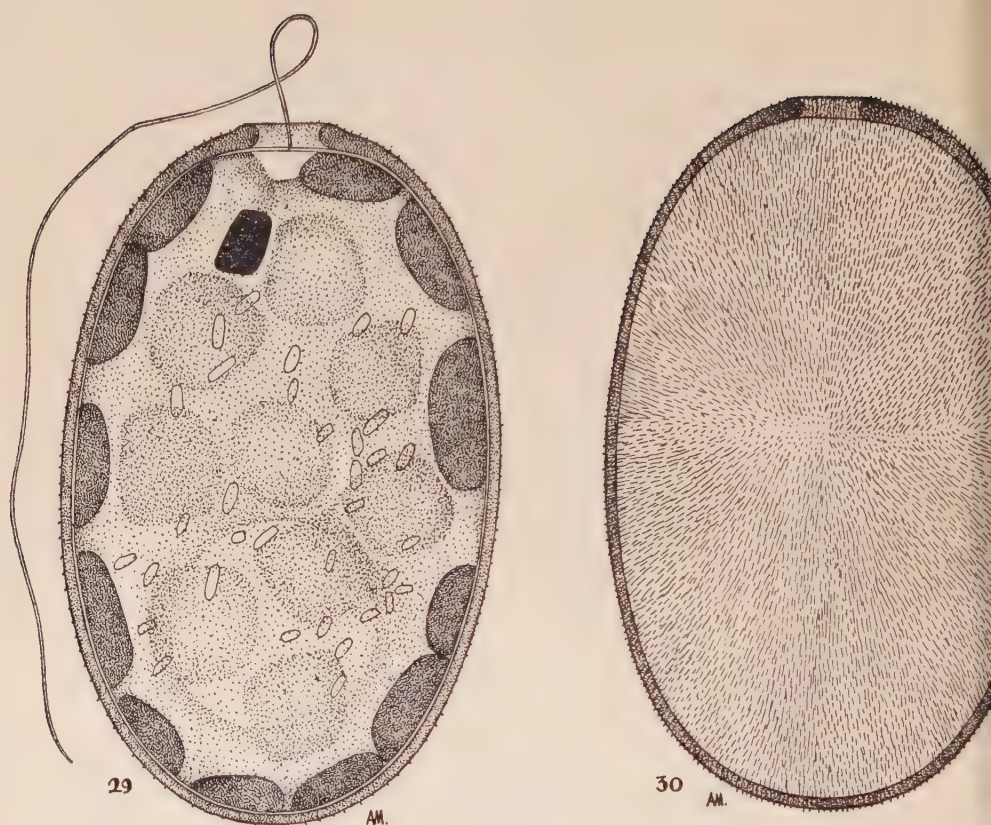
Fig. 4

Strombomonas affinis (Lemm.) Defl.?

Pl. II, ff. 19, 20.

Cette espèce semble n'avoir été étudiée qu'en un seul exemplaire par Lemmermann (Deflandre, Strombomonas nouveau genre d'Euglénacées, p. 590.). J'ai trouvé cette espèce en une dizaine d'exemplaires dans le fossé du château „Aldenghoor" à Haelen (Limbourg). Le contour ondulé de la loge est dû à des enfoncements réguliers. La forme de la loge est ellipsoîdale, munie d'une queue et d'un col. Membrane lisse, relativement mince, d'une couleur brun-violet.

Chromatophores 10—12, discoîdaux.

Flagellum une fois la longueur de la loge.

Long. tot. 41 μ, larg. 20,5 μ.

Haelen (Limbourg), 21/7/43.

Bien que Lemmermann disse „Gehäuse zylindrisch", je crois

que la forme que j'ai observée est, vu son aspect total, identique à la **Tr.** affinis de Lemmermann.

Strombomonas tambowika (Swir.) Defl.

Pl. II, *f* 24, Pl. III, ff. 25, 26, Pl. V, ff. 31—60.

Dans „Die Euglenaceengattung Trachelomonas, Arch. f. Hydrob. u. Planktonkunde, Bd. IX, 1914, p. 647", Swirenko décrit une Tr. tambowika au moyen du diagnose suivant:

„Testa ovalis vel obovata flavo-brunnea, parte anteriore attenuata et collare recto elongata, margo collaris dentata. Parte posteriore caudis longis rectis sive arcuatis armata. Membrana levis, sed irregulariter rugosa".

Le matériel était fixé, et il ne donne pas de particularités de la cellule.

Dans letang „de Kolk" à Enschedé pullule une espèce qui figure ici et qui est, quant à sa loge, identique au diagnose et aux dessins de Swirenko.

Vue de front, la loge est trapézoîdale, très variable de forme, et circulaire en vue apicale; elle est munie d'un col, à bord denticulé, et d'une queue plus ou moins longue, droite ou courbée.

La membrane est mince, jaune-clair ou brun-jaunâtre, pourvue de rides irrégulières, caractéristiques; elle présente des verrues irrégulières, et çà et là sont disséminés des grains de grosseur variable. La cellule contient une foule de chromatophores discoîdaux, gui laissent libre le pôle antérieur.

Stigme rélativement petit, flagellum environ une fois plus long que la cellule qui ei ne remplit qu'une partie minime de la loge.

De nombreux individus étai ent au stade de la bipartition et je rencontrai divers exemplaires contenant des spores durables (fig. 25).

Jamais je ne vis un individu en mouvement. Seul la cellule se mouvait dans l'espace libre de lo loge.

La longueur totale de la loge est généralement de 50 μ, la largeur de 26—30 μ.

Une étude s'étendant à des centaines d'exemplaires a révélé que la variabilité de la loge est extrêmement étendue.

Les exemplaires trouvés montraient des formes intermédiaires entre des loges à rides irrégulières et des loges lisses à longues queue. Il y a également des formes intermédiaires entre les espèces comme Str. verrucosa (Daday) Defl., Str. zmiewika (Swir.) Defl. et Str. Girardiana (Playfair) Defl. (voir fig. 31 à 60 provenant d'une seule récolte!).

Dans son étude sur le genre Strombomonas, Deflandre supposait déja qu'il existe une affinité étroite entre les formes citées. Je ne veux pas encore tirer des conclusions prématurées: il est nécessaire de confronter les données existantes avec celles que fourniront de nombreuses récoltes provenant d'ailleurs.
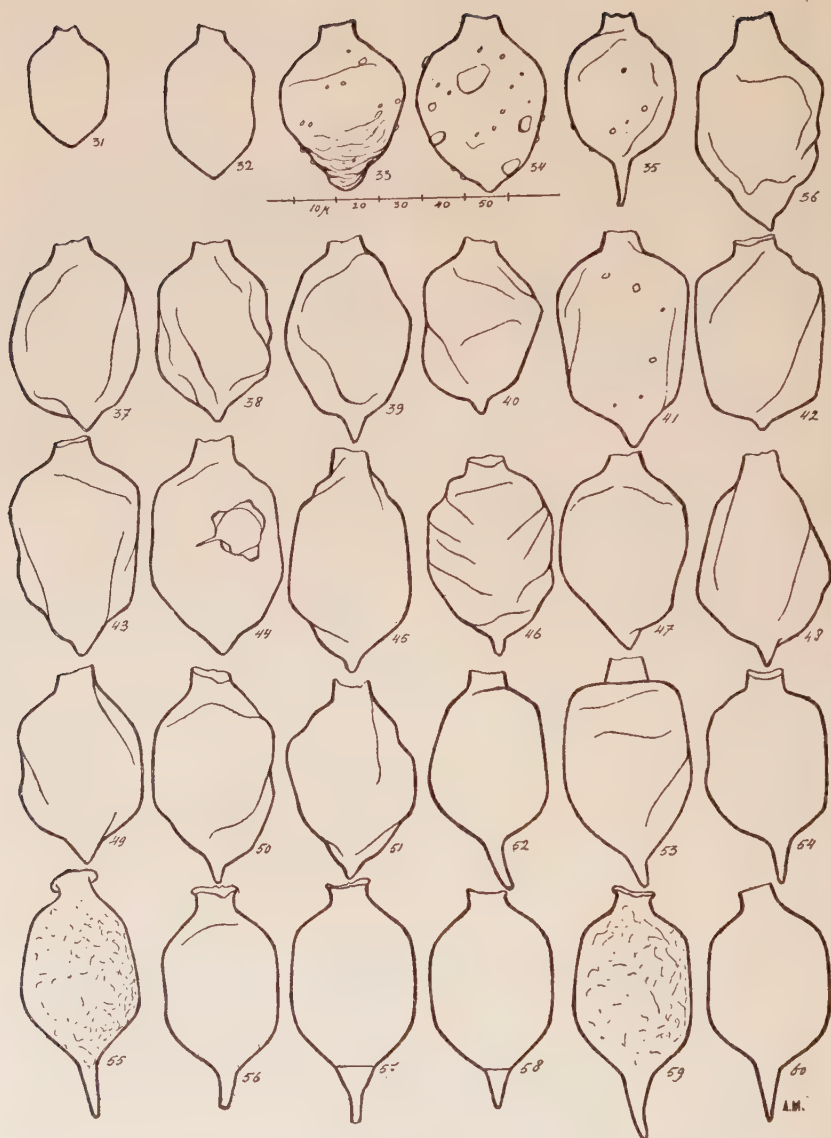
Fig. 5

Les formes à queue longue et séparée du corps par une mince membrane transversale sont remarquables (voir Deflandre Monographie, fig. 762) ; Pl. V, ff. 57, 58.

Enschede, étang „de Kolk", 16/10/45, 19/7/46, très fréquente, pH = 6.

Trachelomonas tuberculata nov. spec.

Pl. I, ff, 7—10.

Lorica obovata, ellipsoïdea, subsphaerica, antice in forma typica deplanata, regulariter tuberibus robustis instructa, porus quinque tuberibus circumdatus, collo nullo vel per exiguo. Membrana crassa, nonnunquam versus porum incrassata, luteo-brunnea vel rubis-brunnea. Chromatophora dua.

Flagellum triplo longius quam lorica.

Long. 19—24 μ, lat. 20—22 μ.

In fossa Enschede 4/5/1941, frequens.

Matériel au „Leids Herbarium".

Trachelomonas tubantia nov. spec.

Pl. II, ff. 21—23.

Lorica perfecte sphaerica, collo recto cylindrico, irregulariter crenulato. Membrana tenuis cum collo verrucis irregularibus et granulis irregularibus instructa.

Chromatophora plura (10—12). Membrana luteo-brunnea.

Long. tot. 32—36 μ, lat. 26—30 μ, collo long. 6 μ, lat. 6 μ.

Enschede „de Kolk", 16/10/45, 19/7/46, rarissima.

Nomen geographicum regionis „Twente", in lingua latina Tubantia".

Matériel au „Leids Herbarium".

Trachelomonas splendidissima nov. spec.

Lorica anguste ellipsoïdea vel cylindrica, polis late rotundatis, polo posteriore papilla instructa, collo recto vel inclinato cylindrico, marga colli irregulariter lacertus, se proferens in partem internam loricae. Membrana tenuis in totam superficiam granulis densis praedita luteo-brunnea vel brunnea, in juventute levis et hyalina, collum in colore clariore quam lorica. Chromatophora discoïdea (10—12) in pariete jacens.

Nucleus in parte posteriore.

Protoplasta valde metabolica.

Long. tot. 32—38 μ, lat. 21—24 μ, collo long. 4 μ, lat. 6 μ.

„'t Stokhorst", Enschede 1/12/45, 19/2/46, frequens. Amersfoort 24/3/46.

Les spécimens du matériel de l'étang „'t Stokhorst" doivent être considérés comme des paratypes.

Matériel au „Leids Herbarium".

BALECH E.) — Trachelomonas de la Argentina. Protistologia, publicacio No. 5, Buenos Aires, 1944. 1944.

Flagellates nouveaux ou peu connus (CONRAD, W. — Formes nouvelles du genre Trachelomonas Ehrbg.) Arch. f. Protistenkunde, 78. Bd., 1932.

Deflandre (G.) — Monographie du genre Trachelomonas Ehrbg. Nemours, 1926.

„ Strombomonas nouveau genre d'Euglénacées. Arch. f. Protistenkunde, 69. Bd., Heft 3, 1930.

„ Observations sur les mouvements propres, pistes et vitesses de déplacement de quelques Protistes. Annales de Protistologie, Vol. II, Fasc. 1, 1929.

Lemmermann (E.) — Kryptogamenflora der Mark Brandenburg. Bd. 3. Leipzig, 1910.

Oye (P. van) — De Euglenaceae van Java, 1922.

Palmer (T. Ch.) — Delaware Valley forms of Trachelomonas. Proc. of the Ac. of the Nat. Sc. of Philadelphia, 1915.

Redeke (H. C.) — Synopsis van het Nederlandsche zoet- en brakwater-plankton. 1935.

Stein — Organismus d. Infusionsthiere. Leipzig, 1878.

Swirenko (D.) — Zur Kenntnis der russischen Algenflora. I. Die Euglenaceengattung Trachelomonas. Arch. f. Hydrob. u. Planktonkunde, Bd. IX, 1914.

„ Eugleninae, 1939.

Explication des figures.

Planche I.

Fig. 1, 2, 3. Trachelomonas aplanata Drezepolski.
Glanerbrug, 24/11/45.
1.   Vue frontale.
2.   Vue frontale avec plan de séparation.
3.   Vue apicale avec plan de séparation.
4, 5, 6. Trachelomonas Stokesiana Palmer.
Enschede „'t Wooldrik" 12/1/46.
4.   Vue frontale.
5.   Pôle postérieur.
6.   Vue apicale (pro parte).
7, 8, 9, 10. Trachelomonas tuberculata nov. spec.
Enschede, 4/5/41.
7.   Vue frontale avec la cellule.
8.   Individu subsphérique aplati.
9.   Pore.
10.   Coupe optique médiane, forme typique.
11, 12.   Trachelomonas splendidissima nov. spec.
Enschede „'t Stokhorst", 19/2/46.
11.   Vue frontale, forme typique adulte.
12.   Coupe optique médiane, jeune individu.
13.   Trachelomonas acanthostoma Stokes.
Enschede „'t Stokhorst", 19/12/46.

Thermal - vegetation and ecological - valences theory

by Prof. Dr. V. VOUK (*Zagreb*, Yugoslavia)

In my earlier studies about thermal-vegetation, especially in my works ,,Vergleichende biologische Studien über Thermen" and ,,Ueber die Kardinalpunkte des Lebens", I draw the attention to the difficulties in the general characterization of the thermal organisms in connection with the temperature-factor and with the classification of thermal biocoenosis.

HANSGIRG and also VOUK distinguished thermophil and thermal organisms, ELENKIN (1914) hypo-, meso-, and euthermophil formations, STROUHAL (1934) thermobionts, thermophil and thermoxen organisms, and ELENKIN (1936) frigidophile and thermophile caenosis. This different conception and characterization, and also the confusion in distinguishing some ecological types is due to the fact that at the characterization of the types the *temperature optimum* of the best development of thermal organisms had not beenc onsidered, namely that temperature at which the thermal organisms appear mostly in the natural conditions. Every organism has its own cardinal-points for each factor of its life: minimum, optimum and maximum. Minimum and maximum are the end-points between which organisms appear, but there is an optimum, at which the organism mostly appears, it means that this optimal point is in the same time the most convenient one for its development. This optimum is not always in the equal relation to minimum and maximum. Sometimes the optimum is nearer to the minimum and sometimes to the maximum. The relation of the cardinal-points may be different. *This reciprocal relation of all the three cardinal-points of one factor is called ecological valence.* In the mentioned work about cardinal-points of life, I took notice, that for instance thermobiont organism, as STROUHAL tells, have eurytherm characters, but with more or less lower optimum, on the other hand the thermophil organism (thermal by HANSGIRG) are stenotherm and eurytherm types with more or less higher optimum, and finally thermoxen organisms (by STROUHAL) *are* eurytherm organisms with a very low optimum, as for instance some Diatomeae or Desmidiaceae. The Elenkin's classification in hypo-, meso-, and eurytherm-formations (coenosis) regards only the limiting cardinal-points without consideration of optimum. So, in a hypothermophil caenosis we find true thermophil

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organisms of eurytherm character, and in another eurytherm coenosis, some thermoxen organisms with lower optimum. In order to clear this complicated relation of different types of thermal caenosis, it is necessary to know our system of ecological-valences, as above mentioned.

We differ six possible valences two groups:

1) *Stenovalent types:*

Microstenovalent types with low optimum. (Fig. 1., a)
Mesostenovalent types with middle optimum. (Fig. 1., b)
Macrostenovalent types with high optimum. (Fig. 1., c)

2) *Euryvalent types:*

Microeuryvalent types with low optimum. (Fig. 1., 1)
Mesoeuryvalent types with middle optimum. (Fig. 1., 2)
Macroeuryvalent types with high optimum. (Fig. 1., 3)

Fig. 1
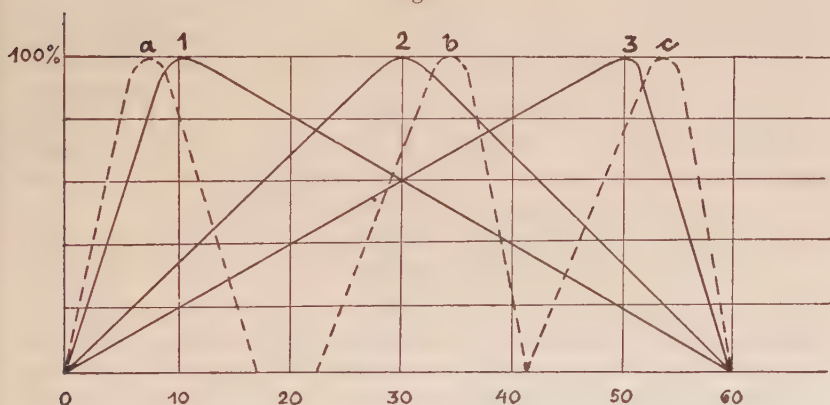
Fig. 1. Schematic illustration of different types of ecological valences. 1) microeuryvalent, 2) mesoeuryvalent, 3) macroeuryvalent types. a) microstenovalent, b) mesostenovalent, and c) macrostenovalent types.

The valences are represented at the illustrating scheme in Fig. 1. Certainly, the optimum is variable although determined, so that every valence-curve will be different, but more or less comforming to the above scheme.

Temperature limits for life i.e. the activ life move between 5⁰ and 79⁰ C. and as it is known today in this space are found organisms with different temperature-valences. Notorious *cryobionts*, inhabitants of cold waters like *Hydrurus foetidus* or snow-like *Chlamydomonas nivalis* are typical microstenotherm organisms, but the typical thermal organisms like *Mastigocladus laminosus* and *Phormidium laminosum* are stenotherm organisms with higher optimum i. e. macrostenovalent types.

Now, we can see the importance of determining all the three

cardinal-points and especially the optimum, for characterization of the ecovalence of any organism in the community. It is regrettable that at the present time the thermovalence of thermal organisms is scarcely known, so that we cannot get the curve of their thermo-valences. The observers and investigators of the thermal vegetation very often noted temperatures, at which some species occur, but from these data we cannot decide positively their thermo-valence and especially their optimum of occurence, which is the most necessary for characterization of eco-

Fig. 2

Synechococcus elongatus var. amphigranulatus — I
Phormidium tenue var. granuliferum — II
Synechococcus elongatus var. vestitus — III
Synechococcus lividus — IV
Synechococcus Minervae — V
Synechococcus viridissimum — VI
Phormidium bijahensis — VII
Synechococcus vulcanus var. bacillarioides — VIII
Synechococcus Vulcanus — IX
Oscillatoria filiformis — X
Phormidium geysericola — XI
Synechococcus eximius — XII

Fig. 2. Thermovalence of some Algae of thermal waters of Yellowstone after COPELAND, comp. by VOUK).

type. The most confident data we have found in the treatise of COPELAND (1937) about the thermal algae of Yellowstone (U. S.A.) Supported by data of COPELAND, we put here the following delineation, which represents the thermo-valence of some thermal Cyanophyceae: *Synechococcus elongatus* var. *vestitus* and perhaps var. *amphigranulatus* can be treated as mesostenotherm types, but *Synechococcus vulcanus* var. *bacillarioides, Oscillatoria filiformis, Phormidium geysericola* and *Synechococcus eximius,* are distinctly macrostenotherm types. *Synechoccoccus lividus, S. Minervae, S. viridissimum Phormidium bijahensis* are more or less macroeurytherm types with their optimum at cca. 50° C. Here are represented more or less macrovalent types. Still the typical algae of the genus *Oscillatoria* and *Phormidium,* distributed in the thermal waters of Europe belong more or less to the mesovalent group i.e. mesoeuryvalent types. All these data were obtained by observing in nature and are not based on the exact research of cardinal points on the laboratory-experiments as it should be, if we want to get the exact data. For the same purpose, the differential-thermostate in the construction of VOUK and KLAS, will render a good service to the future investigators. Such investigations will be important if

we want to get a true insight into the compounding of thermal
vegetation with regard to thermo-valence of composed elements
of vegetation. The thermoxen elements will be shown as micro-
euryvalent types, and the thermal organisms will be represented
as mesovalent types. With the same application of the theory
of ecovalence we shall obtain a clear and distinct insight into
the relations of these organisms to temperature. Thus we are
comming to the exact distinction between the cold-waters orga-
nisms i.e. *psychrobionts* and the organisms of thermal-waters
i.e. *thermobionts*. In the added Fig. 3 we sec the illustration of
thermal relations between psychrobionts and thermobionts. As
a limit we put the temperature of 25° C, as the experiences in
nature are given, but according to ELENKIN we could design this
as hypothermal range. Analogous limitation we put at 55° C
between eutherm and hyperthermal sphere. Below this figure

Fig. 3
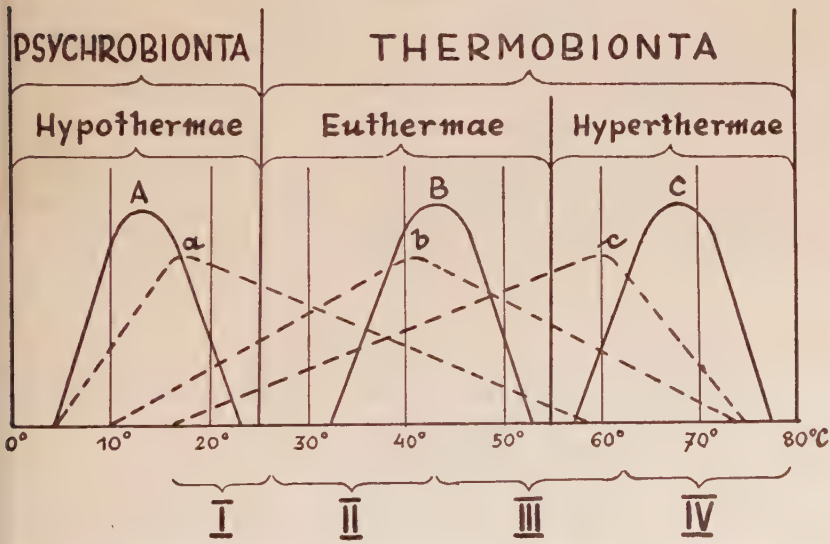
Fig. 3. Schematic illustration of thermal caenosis. I. Chliarothermae,
II. Euthermae, III. Acrothermae, IV. Hyperthermae.

we designed the division of thermal waters as we divided them
sometime ago, and as it is usual in the thermal literature now.
This older division is only partly according to the new division
from the point of view of ecovalence, which is not surprising,
because the division of thermal waters, according to human
temperature-sense, must not aggree with the division of orga-
nisms from the point of view of their ecovalence. The distribu-
tion of some types in different ranges is evident, for instance,
the psychrobiont vegetation can be composed partly of meso-
thermovalent, even of macrothermovalent types, though they

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find themselves in their minimum of development. Thus cross the types of different valences, macrovalent the same as microvalent, in the euthermal range. The characterization of vegetation is determined through the number of elements in the optimum. The communities of thermobionts are subsequently composed of:

1) mesostenovalent (B) and macrostenovalent (C) types, generally called thermobionts,
2) mesoeuryvalent (b) and macroeuryvalent (c) types, generally known as thermophils,
3) microeuryvalent (a) types, generally called thermoxene or frigidophil types.

With this scheme the distinction between psychrobionts and thermobionts becoms evident.

The*psychrobionts* are organisms, whose optimum lies in hypothermal range, and *thermobionts* are organisms, whose optimum is in hyperthermal or euthermal range. At last we distinguish *euthermobionts* with the range of $25°$ C—$55°$ C, and *hyperthermobionts* over $55°$ C. These are very seldom in nature.

In applying this division, based on ecovalences, to life-communities, we can distinguish:

I. *The psychrobiontic communities or psychrocoenosis* composed generally of microstenovalent and microeuryvalent types, and occasionally of meso-and macroeryvalent types.
II. *The thermobiontic communities or thermocoenosis*, i.e.
   1) *euthermocoenosis*, composed generally of mesostenovalent and mesoeuryvalent thermobionts, occasionally supplied with macroeuryvalent thermobionts and microeuryvalent psychrobionts,
   2) *hyperthermocoenosis*, composed of macrostenotherm and macroeuryvalent thermobionts, occasionally also of mesoeuryvalent thermobionts.

Of course this scheme does not exist in nature, but there are many of these possibilities. So, for instance, the chliarotherms (after VOUK) i.e. luke-warm springs with temperature from $18°$ C to $28°$ C, in nature very often, are standing on the limit between hypothermal and euthermal range, and are consisting of psychrobions and thermobionts. If we want to design the vegetation of such chliarotherms as psychrocoenosis or thermocoenosis it will depend upon the predomination of one or of the other elements. The chliarotherm of relict characters are generally thermocoenosis. We find the classic example of such thermocaenosis in hypothermal range in thiothermal-vegetation of Split (the harbour on the Adriatic coast of Yugoslavia) presented by ZORA KLAS. Typical examples of hyperthermocoenosis can be found in the hot-waters of Yellowstone (J. COPELAND) The possibility of finding psychrocoenosis in euthermal range

is not excluded, just as euthermocoenosis in hyperthermal range. In each case is decisive for characterization *the optimum* of the thermal type.

Therefore I think, that the application of the theory of ecovalences on the thermal-vegetation gives a clearer insight into the relations of these communities, concerning the temperature as a limiting factor, and according to this, its more exact classification.

LITERATURE.

COPELAND J. J.: Yellowstone Thermal Myxophyceae.
Annals New York Acad. of Science Vol. XXXVI, 1937.

ELENKIN A. A.: Ueber die thermophilen Algen-Formationen (Russ. und deutsch) Bull. Jard. Bot. Pierre le Grand, Peterburg XIV, 1914.

   ,,   ,, : Die Süsswasseralgen Kamtschatkas. Abh. d. Kamtschatka-Expedition von Rjabuschinski. Bot. Abt. 3 (1914).

   ,,   ,, : Monographia algarum Cyanophycearum aquidulcium et terrestrium in finibus SSSR. Paris I Generalis (Russ.).

HANSGIRG A. : Beiträge zur Kenntnis der böhmischen Thermalalgenflora. Oesterr. bot. Zeitschrift XXXIV 1884.

KLAS Z. : Die thiothermale Vegetation im Hafen von Split. Acta Adriatica Inst. oceanogr. Split, II, 2, 1938.

  ,,   ,, : Neue Lichtthermostate für pflanzenphysiologische Untersuchungen. Acta Botanica, inst. bot. Zagreb, vol. X. 1935.

STROUHAL H. : Biologische Untersuchungen an den Thermen von Warmbad Villach in Kärnten. Arch. f. Hydrobiologie XXVI. 1934.

VOUK V. : Vergleichende biologische Studien über Thermen. Bull. Acad. of Scien. Yugosl. Zagreb, XXII, 1937.

  ,,   ,, : Ueber Kardinalpunkte des Lebens. Ein Beitrag zur Kenntnis der oekologischen Valenzen.
Bull. Acad. Scien. Yugosl. Zagrab, XXXII, 1939.

Bibliographie

PRINGSHEIM, E. G. *Pure Cultures of Algae, their Preparation and Maintenance.* Cambridge Universty Press. 1946, XII + 120 pages, I portrait; Préface de F. E. FRITSCH.

Suivant la conception pasteurienne la culture pure est celle qui ne contient qu'une seule espèce d'organisme, elle provient d'une cellule unique. Les progrès techniques ont permis d'obtenir des cultures pures d'un nombre considérable de Bactériacées les plus variées, de Mycètes, Protozoaires, Algues, Mousses, phanérogames, insectes, tissus, etc. Avec les auteurs français nous pensons qu'il faut garder à la notion de culture pure son acception stricte. Dans cet ordre d'idées, nous eussions préféré que le très remarquable travail de PRINGSHEIM fut intitulé simplement: *Cultures of algae, their preparation* etc.

En fait, les cultures pures d'algues sont relativement peu nombreuses, ce sont celles réalisées d'abord par BEIJERINCK (dont le portrait placé en tête du livre est un hommage très justifié ensuite, celles de R. CHODAT, de VISSCHER W. et d'autres; on y trouve surtout des Chlorophycées et des Xanthophycées. Parmi les autres classes d'algues, les vraies cultures pures sont exceptionelles. PRINGSHEIM, à la fin de son ouvrage donne une bonne mise au point des résultats obtenus.

Dans le domaine de la culture pure à peu près tout reste à faire; les résultats obtenus ne sont pas en rapport avec les efforts qui ont été déployés, aussi est-ce avec un certain scepticisme que d'aucuns ont apprécié la valeur des cultures pures. C'est ce que fait remarquer le professeur FRITSCH dans les pages magistrales par lesquelles il présente le travail de PRINGSHEIM. Le grand algologue anglais fait très bien ressortir le grand intérêt et l'originalité des recherches de PRINGSHEIM qui, appréciant la diversité des facteurs écologiques qui règlent l'existence des algues, a su adapter sa technique de culture aux besoins individuels des algues ou Flagellates.

Pour le prof. FRITSCH, PRINGSHEIM a reconnu le fait fondamental qu'il n'est pas nécessaire d'avoir des cultures d'algues absolument pures, que l'on peut tolérer des bactéries sauf pour des buts spéciaux tels que des recherches physiologiques. De là, en se plaçant à un point de vue algologique, l'intérêt considérable des cultures „terre+eau" dans lesquelles les algues trouvent des conditions plus naturelles de vie. Les travaux récents de PRINGSHEIM (I) illustrent cette appréciation et montrent les ressources qu'offre la technique, mise au point par PRINGSHEIM.

La voie nouvelle ainsi ouverte est encourageante. Les cultures unialgales forment un matériel abondant à la disposition des chercheurs, elles se prêtent à une étude cytologique et écologique plus étendue. Ces cultures brutes serviront à l'obtention de cultures pures véritables et constituent une étape qui semble nécessaire pour arriver d'abord à une analyse exacte des conditions physiologiques vitales des algues. Ce n'est que quand cette analyse sera assez poussée que l'on pourra espérer faire une synthèse générale dont l'intérêt est tout à la fois physiologique et écologique.

PRINGSHEIM donne dans son livre des renseignements très détaillés sur les techniques à suivre : choix du matériel, cultures d'enrichissement, techniques spéciales d'isolement. Dans divers chapitres, il traite successivement des milieux à employer : la constitution des solutions et milieux nutritifs, la culture sur plaques de Petri, la technique de purification et d'isolement à la pipette, la multiplication et la conservation des cultures, des conseils sur l'éclairage. Un index facilite la consultation de l'ouvrage. Enfin, une série de références bibliographiques intéressantes pour ceux qui désirent avoir des renseignements détaillés de la littérature germanique. Quelques travaux récents anglais et américains complètent cet ensemble. S'il y a quelques lacunes, par exemple, les travaux de LEFEVRE M. (2), cela provient probablement des difficultés actuelles de documentation.

Signalons particulièrement les techniques les plus intéressantes préconisées par PRINGSHEIM : les cultures „terre+eau" (soil and water cultures) et les isolements à la pipetted inspirés par la technique de A. LWOFF.

Les cultures „terre+eau" se font en tubes à essais. On met dans le fond du tube 3 à 5 grains de blé ou d'orge, que l'on peut remplacer par une même quantité d'amidon à laquelle on ajoutera un peu de craie. On introduit ensuite dans le tube sur une hauteur de 3 à 5 c m. de la terre de jardin (qui ne doit pas être trop riche en argile ou en humus). On verse de l'eau jusqu' à environ 4 cm. du bord du tube qui est enfin garni d'un bouchon d'ouate. On place les tubes ainsi préparés dans un étuve à vapeur froide et l'on porte lentement à l'ébullition. On reste à cette température au moins 3 heures. L'ensemencement se fait le jour suivant; on ne doit pas attendre plus de 8 ou 15 jours pour ensemencer.

Cette technique peut être modifiée suivant les besoins en ajoutant des substances putréfiables telles que du fromage, gélatine, peptones, etc; l'emploi d'argile pauvre en humus au lieu de terre de jardin favorise certaines espèces exigeantes; on utilisera de la tourbe de Sphagnum ou lignifiée; d'autres fois de la terre humifère sans amidon ou grains de céréales a été trouvée intéressante. Ces quelques exemples montrent comment on peut varier les conditions de milieu et obtenir des espèces variées.

Ces milieux sont ensemencés avec des algues que l'on soumet à des traitements préalables visant à éliminer le plus possible les bactéries. On utilise dans ce but: la centrifugation, les mouvements photo- ou géotactiques des zoospores et des Flagellés, la production de zoospores, etc. Une technique sur laquelle PRINGSHEIM insiste tout particulièrement est l'ensemencement à la pipette d'une seule cellule ou pour les formes filamenteuses, le prélèvement avec un crochet formé par l'extrémité d'une pipette courbée à angle droit dans la flamme d'une veilleuse. Les algues enlevées à la pipette (3) sont, autant que possible, prélevées dans un état de sporulation, de mobilité (absence fréquente de bactéries). Les stades palmelloïdes sont à éviter, les gelées étant toujours contaminées. Le chapitre V donne la technique à suivre pour le lavage des algues isolées: dans une série de verres de montre on a préparé de l'eau ou un liquide nutritif stérile; on passe l'algue succesivement d'un liquide à l'autre. A chaque passage, les bactéries sont diluées et finalement on obtient l'algue débarassée de germes microbiens. Cette technique a été d'abord employée par LWOFF, A. Cette méthode demande de l'adresse et PRINGSHEIM examine en détail les différentes causes d'insuccès, il insiste sur les précautions à prendre.

Le chapitre IV traite des procédés à suivre pour obtenir des cultures pures. PRINGSHEIM préfère ensemencer la surface de la gélose et utilise un vaporisateur (voir sa figure 8, p. 63). Il ne conseille pas les méthodes de dilution habituellement usitées par les bactériologistes. Tout cela est accompagné d'une profusion de détails de technique dont l'observation est nécessaire. Ajoutons que celui qui veut s'initier à la difficile besogne d'obtenir des algues en culture pure (nous savons de science personnelle qu'il en est bien ainsi) trouvera dans le travail de PRINGSHEIM des indications sur les milieux à employer et la relation bien exposée, quoique condensée, de nombreux travaux et expériences d'algologues. Les spécialistes en la matière auront toute satisfaction à lire cet ouvrage et à s'en inspirer.

H. KUFFERATH.

[1]   PRINGSHEIM, E. G. Contribution to our knowledge of saprophytic Algae and Flagellates, III, Astasia, Distigma, Menoidium and Rhodomonas. New Phytologist, 1942, Vol. 41, p. 171.
[2]   LEFEVRE, M. De la valeur des caractères spécifiques chez quelques Eugléniens. Travaux cryptogamiques à Louis MANGIN, 1931, p. 343.
Recherches sur la biologie et la systématique de quelques Algues obtenues en culture. Revue algologique, 1932, T. VI, p. 313.
Recherches expérimentales sur le polymorphisme et la tératologie des Desmidiées. Ed. P. Lechevalier Paris, 1939.
[3]   Voir aussi la pêche au moyen de pipettes suivant les indications de TCHAKHOTINE, La microinstrumentation pour les recherches de cytologie expérimentale. Bull. Soc. française de Microscopie, 1935, T. IV, p. 138.

*E. Teiling Staurastrum planctonicum and St. pingue. A study of
planktic evolution.* Ex Svensk Botanisk Tidskrift, 42, 2, 1947.

Summary. 1. The two old species Staurastrum Manfeldtii and
St. Sebaldo are discussed. In separating these closely allied spe-
cies, connected by intermediate forms and often mixed up, the
author stresses the shape of the corpus and the terminal orna-
ment of the processes. The ornament of the corpus is to varying
to be used as a specific character.
2. Some details in the morphology of the desmids, which are
subject to great variations and offer important indications of
genetic relationships, are dealt with. Among the plankters of
the St. Gracileparadoxum-section, forked spinae (verrucae) can
be reduced to granula-pairs (granula bigemina) or to simple
spines and can also be totally reduced. These protuberances are
homologuous. Staurastra without complete apical-marginal rows
of verrucae are derived from forms with rows of verrucae from
process to process. Lateral granula are also subject to reduction
in planktic living.
3. Taking into consideration the reduction by the varia-
tion and the selection of the planktic living, the author
derives some plankters from benthic desmids. Two series are
established, one from St. Manfeldtii to St. pingue with St. Luet-
kemuelleri as an intermediate form, the other from St. Sebaldi
var. ornatum to St. planctonicum with f. planctonica as an
intermediate form.
4. Certain plankters, formerly regarded as St. gracile, are con-
sidered to represent reduced forms, now included in St. plancto-
nicum. Staurastrum Duacense may be a biradiate form of St.
Sebaldi var. ornatum. Staurastrum pseudosebaldi is to be re-
garded as an artificial species. It includes forms of St. Man-
feldtii and St. Sebaldi with a lateral row of forked spines.

E. Teiling. Staurodesmus, genus novum. Ex Botaniska
Notiser 1948.

Summary. The monospinous desmids belong to the genera Ar-
throdesmus and Staurastrum and form a common border region
of both. The great resemblance in shape between forms of
Arthrodesmus Incus sensu latissimo and certain monospinous
Staurastra makes it probable that this resemblance depends on
genetic identity. The author has investigated this problem.
First a recapitulation is given of the history of the genus'
namens and how the present division of the monospinous forms
has arisen. The affinity between similar forms of different
radiation is proved by means of morphology and, above all, by
means of dichotypy. In order to give an expression covering
dichotypy and suitable for attaching to latin names, the name
Janus is propesed.

A survey of forms, now placed in Arthrodesmus and Stau-
rastrum, proved or probably identical is given. A taxonomical
part deals with some bi- and pluriradiate species which in the
author's opinion are identical, a survey is given. Jaculiferus is
a collective species, one part of it being triangularis, of which
the author records 2-, 3- and 4-radiate forms and connecting
Janus-forms, Cuspidatus, sellatus, Spencerianus and O'Mearii
are recorded as bior tritypical by means of connecting Janus-
forms and subtriangularis, indentatus and glabrus are regarded
bitypical on the basis of morphology. The taxonomic analysis
contains many forms, previously separated, which the author
includes in the combined species. Some new forms are distin-
guished.

In order to unite the genetically identical desmids, hitherto
placed in Arthrodesmus and Staurastrum, the author has crea-
ted a new genus Staurodesmus and has indicated its li-
mits and the principles of its nomenclature. In view of the
high taxonomic value of the diverse radiation and also in order
to leave the present species intact, the author has made combi-
ned species. These are divided into subspecies (= the present
species), distinguished by the diverse number of corners of
the semicell. An exposition of the reasons for the high taxono-
mis value of the bi- and pluriradiate characters completes the
paper.

*P. van Oye. Rhizopodes. In: Exploration du Parc National
Albert, Mission* J. Lebrun, fasc. 9, 1948.

Summary. The study of Lebrun's material has enabled the
author to enumerate, within the limits of the Albert National
Park, 23 species of Thecamoebae, 13 of which are new for the
fauna of Congo.

This shows a great poverty of species, and at the same time
a very high proportion of species hitherto unknown for Congo.

Among the material examined, the presence of Nibela Wai-
lesii Deflandre and of Arcella corona van Oye are to be noted.

Lebrun's material is especially important with regard to the
ecological and biogeographical point of view.

Considering the relations between the pH of he environment
and the Rhizopods, it can be stated that the genus Arcella pre-
fers a slightly acid environment, with the exception of certain
euryionic species, especially Arcella vulgaris.

The same applies to the genus Centropyxis, where the species
Centropyxis aculeata and its variety oblonga are euryionic.

The genus Difflugia is also slightly acidophile.

As a whole, Rhizopods are not euryionic; they seem, however,
to be less attached to a determined pH than are the Desmids.

The material examined has enabled the author to make some

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very important conclusions with regard to the geographical distribution of the Rhizopods, which may be summed up as follows:

The presence of the typical species Arcella corona distinguishes the discussed Rhizopodan fauna from that of all other regions of the globe, which fact leads to the conclusion that provinces can be recognized within the arctogaeic and the neonotogaeic regions, as this is the case with the biogeographical regions of the other animal classes.

The general facies of the examined rhizopodan fauna is also peculiar. In giving a list of the genera according to their proportional numbers, the author has attempted to express the facies of the regions and possibly of the provinces as well. This attempt shows without doubt that in the future, when more data will be available, it will be possible to thus represent the facies with sufficient exactitude to characterize the rhizopodan fauna of the various regions and provinces.

Shang-Hao-Ley. Heleoplanktonic Algae of North Kwangtung. Botanical Bulletin of Academia Sinica, 1, Dec. 1947, 270—282, 1 fig.

Descriptions and list of heleoplanktonic algae from certain artificial ponds used for irrigation, where, provided the water is not pumped off, planktonic algae become the chief constituent of the flora. The ponds examined were located in the hilly district of Lochang, North Kwangtung, China. The species listed have been preserved in 2—4 % formalin and do not include diatoms nor Euglenieae.

As new are described : Scenedesmus mirificus, sp.nov., C. protuberans Fritsch & Rich. f. minor, f. nov. and Sc. rostrato-spinosus Chod. var. kwangtungensis, var. nov. ; Anabaena mediocris Gardner var. minor, var. nov.

Besides, 31 forms are listed as new for China.

Shang-Hao-Ley. New Myxophyceae from Northern Kwangtung. Botanical Bulletin of Academia Sinio, 1, Mch. 1947.

One new genus, Stilocapsa, gen. nov. and four new species, viz. Stilocapsa sinica, sp. nov., Hormothece Jaoi, sp. nov., Anabaena kwangtungensis, sp. nov. and Homoeothrix kwangtungensis, sp. nov., are described, collected in different localities of Pingshek, North Kwangtung, China, in 1940 to 1943.

Shang-Hae-Ley. Thee Vaucheriaceae from Northern Kwantung, Shina. Sinensia, 15, 1—6, 1944, 91—9—, 1 fig.

Descriptive list of thirteen species, varieties and forms of Vaucheriaceae collected from 1940 on near Pingshek, North Kwangtung, China.

Two new species, viz. Vaucheria Jaoi, sp. nov. and Vaucheriopsis, sp. nov., are described. The last is the second known species of the genus Vaucheriopsis.

Shang-Hao-Ley. A chinese species of Hammatoiden (H. sinensis, sp. nov.. Sinensia, 15, 1—6, 1944, 101—103, 1 fig.

A new species of the genus Hammatoidea W. & G. S. West, H. sinensis, sp. nov., is described and figured: it has been aecidentally discovered in the summer of 1941 in the gelatinous envelops of Chaetophora elegans (Roth) Ag. from two small springs near Pingshek, North Kwangtung, China; later, an abundant material has been recorded from the same stations.

Shang-Hao-Ley. New Zygnemataceae from Northern Kwantung, China. Sinensia, 15—1, 1944, 97—100, fig.

From material collected near Pingshek, North Kwangtung, China, in 1940—1943, seven new species of Zygnemataceae are described, viz.: Zygnema kwangtungensis, sp. nov.; Mougeotia subpaludosa, sp. nov.; Spirogyra fragilis Jao f. minor, f. nov.; S. kwangtungensis, sp. nov.; S. spreeiana Rabenh. f. minor, f. nov.; S. pseudogranutata [1]), sp. nov.; S. Jaoi, sp. nov.

K. F. Vaas. On the importance of the freshwater-Flora as fishfood on Java. Vakblad voor Biologen, 27, 3. Mch 1947, 51-58.

Summary. As there are, among he Javanese freshwater fishes, much more phytophageus species than in Europe, it is of great importance to give an account of the representatives of the freshwater flora on which these species are feeding.

These representatives may be divided into five groups, viz.:
1^0 Submerged higher plants, such as Ceratophyllum demersum L., C. submersum L. and Hydrilla verticillata Presl. Important not only as valuable fishfood, but also because they form a substratum for epiphyte algae (vide 4^0); they grow with considerable speed.
2^0 Floating algae. These, especially Spirogyra, Mougeotia and Oedogonium, form a first-class fishfood, as they mostly are covered with epiphytic algae and with detritus where a rich microfauna thrives. In brackish water, Chaetomorpha, Cladophora and Enteromorpha grow, of outstanding value, especially as food used by the ,,bandeng'' (Chanos chanos Forskahl), which became evident in places where these algae have been destroyed to fight the malaria. Vide A. Sunier in Treubia 2, 159,1922 and H. Vos in Nat. Tijdschr. 101, 226, 1941.

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[1] Probably err. pro ,,pseudogranulata''.

3⁰ Bottom algae. Here Oscillatoria, Phormidium and Lyngbia are to be mentioned, along with Bacillaria, Pleurosigma and Gyrosigma, which form flat masses on the bottom to which fish are quite partial. Other forms, e.g. Aphanocapsa and Aphanatheca, form spherical colonies. Vide A. Sunier l.c. en P. van Oye in Hedwigia 64, 268, 1923.

4⁰ Epiphytes. Several important Fish species feed chiefly on epiphytic algae, e.g. the „nilem" (Osteochilus hasselti Cuv. Val.) ; the presence of detritus and of many animal forms (the so-called untrue epiphyton) is to be noted.

5⁰ Plankton. Mostly eaten by young fish, but adults of some species (the „tambakan", Helostoma temmincki Cuv. Val.) feed on it as well. Vide the different papers by Bernard and by P. van Oye, further the results of the German Limnological Sunda-Expedition 1929.

Two aspects of the study of the plankton in Dutch East Indies are discussed in this paper, viz. the planktonic periodicity and the total production with the energy-balance.

a. Periodicity. Earlier authors (Apstein, Nygaard) have pointed out the possibility of a plankton-periodicity in tropical regions, but it was P. van Oye (Int. Rev. H. u. H. 16, 1, 1926; Bot. Jaarb. 20, 93, 1926; Mikrokosmos 22, 1, 1929) who has been able to establish the existence of such periodicity, based on the rainfall; he accepted Kolkwitz's stadia of oligo- to mesosaproby during the wet season and of polysaproby during the dry season, although of course these three types describe in the first place theoretic ideal situations. Author's research shows that in some cases the periodicity is partial, sometimes with regard to the seasons (,,Telaga Warna"), sometimes with regard to the geographical location (,,Rawa Pening").

b. Total production and the energy-balance. The first term is used by the author following the definition of A. Thienemann in Arch. Hydr. Suppl. 2 (Trop. B. Gew. 2), 205, 1931; although Thienemann has pointed out that a period of a year is arbitrary where tropical regions are concerned — which applies to a certain extent to lakes of temperate zones — Juday in Ecology 21, 438, 1940 has nevertheless made calculations concerning the total balance of energy for one year; the author has tried to do the same for the „rawa Pening" and found that the average lifetime of the plankton must be about 3—4 days, depending on the mean temperature; the year-production would be in this case about 400 kg dry organic matters per Ha, against 6240 kg/Ha in the case studied by Juday. The plankton is accordingly much less important in the Indian lake than in the American one which furnishes not more than 5 kg/Ha dry stuff per year against 33 kg/Ha in the „rawa Pening". Author's opinion is that this difference is due to the fact that the ichthyofauna of the „rawa Pening" consists mainly of vegetarian species.

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A. H. Nasr. Synopsis of the marine algae of the Egyptian Red Sea Coast. Bulletin of the Faculty of Science, Fouad I University, No. 26, Cairo 1947, 1—155, XIV pl., 25 ff.

Summary. —

The author gives a short historical account of the subject and then proceeds to a systematical description, with keys and synonymy, of the marine Algae found on the Egyptian Red Sea coast. A very complete bibliography is appended.

Author's conclusions are as follows:

1. The algal flora of the Red Sea is undoubtedly tropical, a fact corroborated by the presence of various members of the Siphonocladales and the complete absence of the Laminariales, which are characteristic features of a tropical flora.

2. The inconspicuousness of all species except a few Fucoideae such as Sargassum and Turbinaria is a characteristic feature of the shore.

3. The diagnoses of classes, orders, families and genera are given with artificial keys wherever possible.

4. The collection examined has 226 species, among which there are 85 new records and 15 species new to science.

5. The following peculiarities are worth mentioning: (a) Phormidium penicillatum, recorded from the Arabian Sea, extends up to Aden, and it has also been found within the area investigated in a new form. (b) Sporochus comosus, a species formerly known from Australia and not yet recorded from he Indian Ocean, has been discovered on the Egyptian Coast of the Red Sea, at the entrance of the Gulf of Suez.. (c) Udotea javensis, a Malayan species which is known as far west as Ceylon, has been found on coral reefs, i.e. a more western locality to its origin.

6. Certain points in the determination of the species, which have for a long time been in doubt, have been cleared up: (a) Experiments have shown that the varieties „clavifera" and „Lamourouxii" of Caulerpa racemosa (Forsk) and others of serrulata are ecologica, not genetica. (b) Hormophysa triquetra (L.) Kütz., a species with many synonyms, has now been defined by the discovery of the reproductive bodies.

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